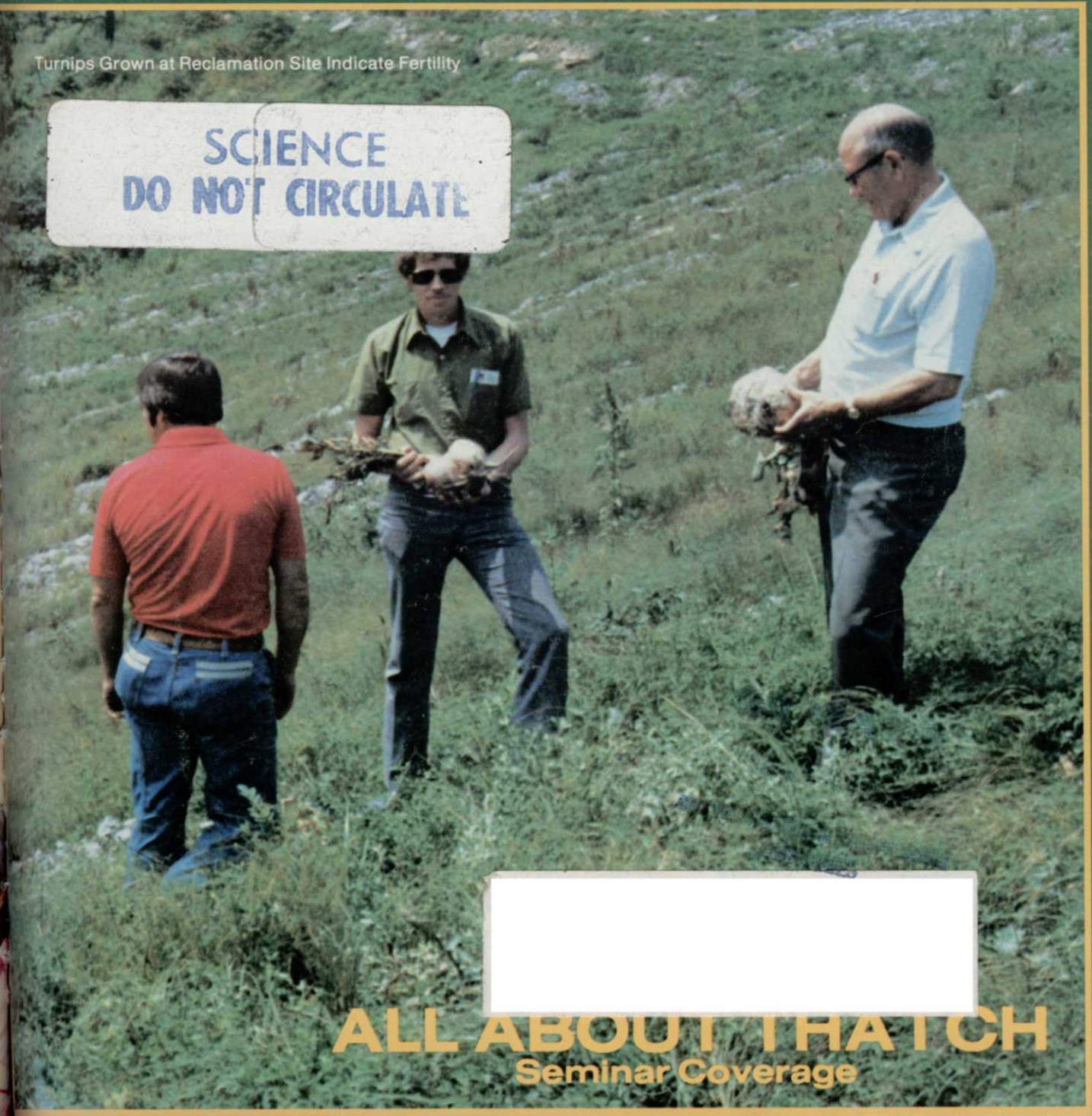
The Business Journal of Vegetation Management April 1979/$1.25

WEEDS TREES & TURF

Transition of Warm Season Grasses

Milky Spore Disease and Chemical Alternatives

Geochemical Factors in Land Reclamation



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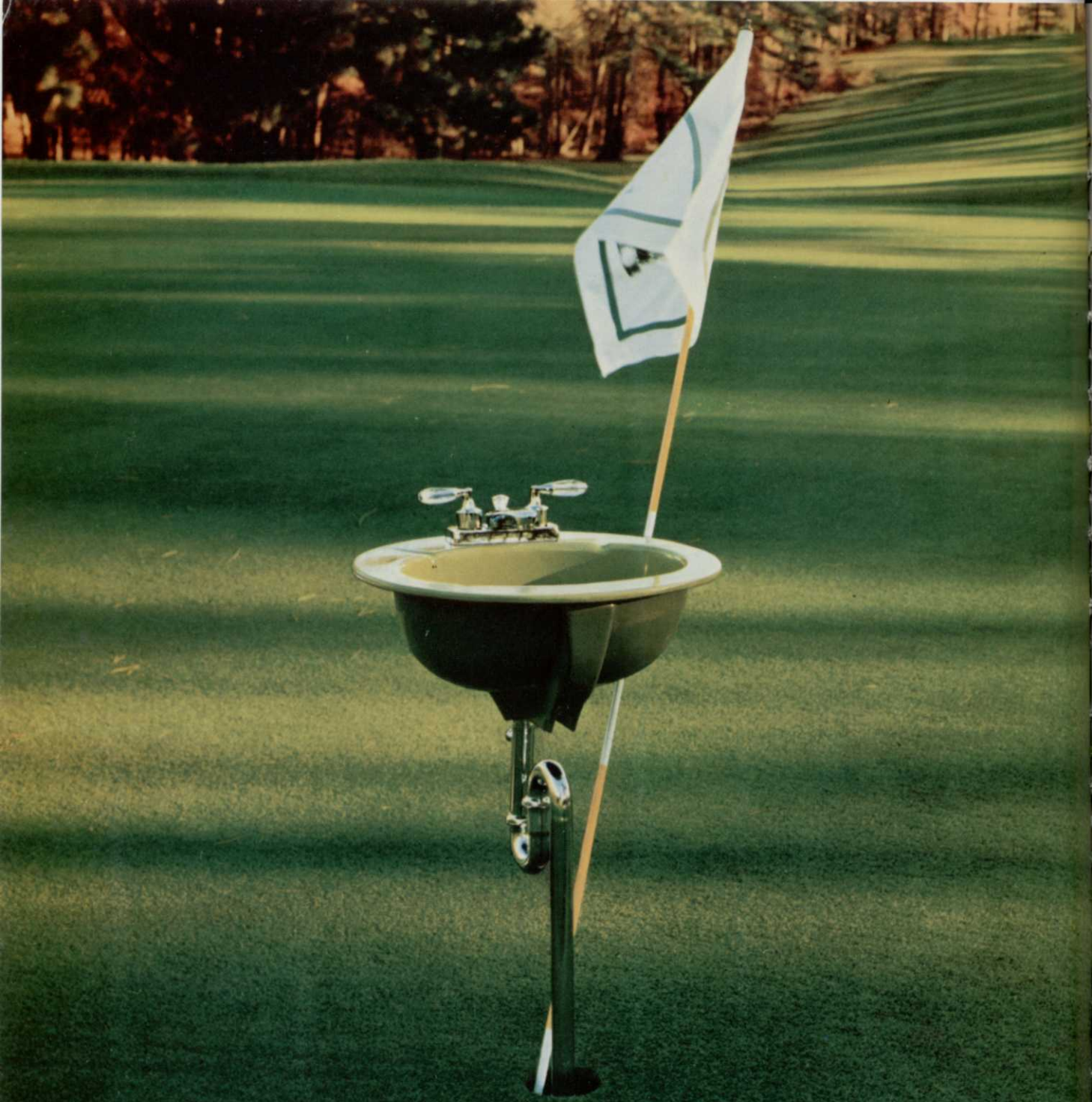

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Cover: Photos courtesy of Northrup King Co. showing that the reclamation site was fertile, as evidenced by the turnips, but the grass didn't take hold as well as anticipated because of poor seeding practices.

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VIEWPOINT

Ron Morris, Technical Editor

It is my habit to scan journals coming across my desk for information that might be newsworthy to the layman in the field. In talking with several authors of articles in our magazine, it has come to my attention that journal articles are a means of recognition for researchers by their supervisors. One author went so far as to say, "They don't care what is in WEEDS TREES & TURF, if it isn't in a journal, it doesn't count."

What a shame, and what a loss to those who depend upon trade magazines for information, and to those who don't receive the journals, aren't aware of them, can't bear the expense of multiple society memberships to receive them, don't have the time to interpret a highly technical journal article, or simply don't understand the language of journals.

It is of extreme benefit to have these scientific articles available to anyone in the scientific community who is interested, for reference, etc. But at the same time, those researchers who go further and present their material to the end user in lay publications like Weeds Trees and Turf ironically fail to achieve the degree of recognition they deserve.

All I am trying to gain is recognition of researchers who publish articles in our magazine. Journal articles are great, but should not always take preference over getting the information to users.

That is our function and we must work with authors to do it. It is also not our habit to make the authors pay for the privilege of being published, quite the contrary. We feel that it is necessary to present up-to-date information to our readers so that they support our function.

We strive to be the "turf journal" that is readable and reaches the most readers with the most significant information. To this end, we wish to have it recognized that those researchers that supply us with articles are performing one of the greatest services of their profession: Supplying you, the end user, with information that helps you carry out your business with the most professionalism possible. **WTT**

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GREEN INDUSTRY NEWS

TURF

Basics emphasized at Virginia Turf Conference

The turfgrass industry has played a major role in increasing the homeowners' expectations and desire to have a perfect, weed-free lawn, according to A. J. Powell. Powell, speaking before 380 persons attending the 19th annual Virginia Turfgrass Conference at the Williamsburg, Virginia conference center, told turf managers that "the turfgrass industry is changing as never before." He noted that although a 100 percent eradication of weeds and crabgrass isn't expected in most areas, it is when the home lawn is the object of the treatment.

He cautioned that lawn managers have to be careful in soil testing. More is needed information about how minerals affect good plant growth, he said. "We don't test for iron because we really don't know how its lack affects growth. This is true in other areas."

"We need a lot of research on how these other minerals affect the growth of turf and determine exactly what their roles are," he added. "We are taking the buffers out of the environment and we should have adequate knowledge as to what is needed."

Palmer Maples of Lawrence, Kan., director of education for the Golf Course Superintendents Association of America, told the largest crowd ever to attend one of the turf conferences that continuing education is necessary in the turfgrass industry, calling it a "tool of management."

Maples noted four reasons why continuing education is needed in the turfgrass industry. They are:

—Government regulations are requiring more and more time and knowledge. Various regulations, local, state and national, are requiring that a turf manager know herbicide and pesticide regulations and their effect on the environment.

—New and more sophisticated equipment are requiring knowledge and skill in their operation. New developments are occurring regularly and a person must learn how to operate the equipment if he wants to do a better job.

—A person has to keep abreast of the management needs of a company and learn how to meet them. Good management is essential in the operation of a firm and the manager must continually keep abreast of the needed procedures.

—Water will become more and more of an issue. The use of effluent water and the ramifications of its use will continue to grow in importance. Knowledge in this area is essential.

Dennis E. Brown of Richmond, supervisor of the seed and sod section of the Virginia Department of Agriculture and Consumer Services warned that closer labelling of seed is essential and called for the increased use of certification to protect the consumer from noxious weeds in their seed.

Joseph P. Harden, former meteorologist-in-charge of the National Weather Service Office in Richmond, observed that there are many sources for weather information for those in the turfgrass industry. Local weather bureaus now have available 30-day forecasts which can prove extremely helpful.

John F. Doss of Suffolk, president of Tidewater Turfgrass Association, presents $500 check to **Richard E. Schmidt,** associate professor of agronomy at Virginia Tech, to be used for development of turfgrass program at Southern Piedmont Research and Continuing Education Center at Blackstone.

Officers of Virginia Turfgrass Council pose for picture after re-election. They are: from left, **Kenneth P. Giedd,** Richmond, vice president; **Rex H. Harris,** Little Creek, assistant secretary-treasurer; **Earl H. Odell,** Chesapeake, vice president; and **Gus C. Constantino,** Richmond, president.

Richard E. Schmidt, associate professor of agronomy at Virginia Tech, traced the outline of the turfgrass program at the University. He noted turfgrass research currently is being conducted at Blacksburg, Blackstone, Langley Air Force Base, Newport News, Orange, Petersburg, Remington and South Hill.

He said there currently are 25 variety evaluation tests, 1 overseeding experiment, 12 fertilization projects, 6 bermuda grass programs, 2 irrigation experiments and 4 sod product projects being conducted.

The final session of the one-and-a-half-day meeting involved separate sessions on golf courses and the basics of nitrogen use and management techniques; general turf and athletic fields and the basic practices in turf management, and the basic practices in lawn service.

The annual meeting was sponsored by the Virginia Cooperative Extension Service, Virginia Tech and the Virginia Turfgrass Council, Inc.

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GOVERNMENT UPDATE

EPA will vigorously enforce Silvex ban

A. E. Conroy II, director of the Pesticides and Toxic Substances Enforcement Division said that enforcement of the Environmental Protection Agency's emergency suspension of 2,4,5-T and Silvex on Feb. 28 will be "vigorous". Suspended uses of all pesticides containing Silvex are: commercial and ornamental turf uses including recreational areas, aquatic weed control and ditch bank uses, forestry uses, rightofways uses, and home and garden uses.

Precautions added to Kerb uses

The Environmental Protection Agency (EPA) has proposed that uses of the pesticide pronamide, marketed as Kerb, be allowed to continue as currently used on turf, commercial nursery plantings, plus some other agronomic crops, but with additional precautions to reduce potential risks to human health. "In general, EPA has concluded that for all uses the economic benefits of pronamide outweigh its risks," Steven Jellinek, assistant administrator said. The benefits come primarily from its use on lettuce and alfalfa. Jellinek added that approximately $17.3 million might be lost by growers.

The use of the pesticide would be restricted to trained applicators wearing protective clothing, and pronamide would be marketed only in water soluble packaging to keep down dust emissions when mixing.

EPA's proposal is not a final action. The proposal will be reviewed by the Agency's Scientific Advisory Panel, the USDA, pronamide registrants, environmental groups and other interested parties. EPA will consider comments in reaching a final decision.

AQUATIC

Abscisic acid helps control pondweed

Lars Anderson, with the U.S. Department of Agriculture, suggests using a plant growth regulator and careful water level management to modify pondweed so it is more susceptible to herbicides. The regulator, abscisic acid (ABA), occurs naturally in some fruits and the herbicides are commercially available.

Current attempts to rid canals of aquatic weeds by using herbicides are not very effective and are limited by lack of chemicals registered by the U.S. Environmental Protection Agency. Herbicides, in order to work, must be added to irrigation water in such huge volumes that the cost is prohibitive or the risk of chemical residues on crops being irrigated is too great.

Pondweed is especially troublesome because it spreads by rhizomes, underground stems that send up shoots which eventually grow into other complete weeds. Cutting or other physical control methods are usually a waste of time and effort. The weeds just grow back as fast, or faster, than they can be removed, or are spread further down the canal.

Normally in spring, pondweed first forms long, narrow submerged leaves, suited for underwater growth. Floating leaves usually are produced later in the season.

Anderson proposes flooding weed-infested irrigation waterways in early spring for 2 to 3 days. After draining the water, pondweed would germinate and begin forming leaves. Under these conditions of waterstress, floating-type leaves are normally formed, or could be induced to form with a spray of ABA which causes pondweed to prematurely produce floating leaves. These leaves are much akin to leaves of terrestrial plants and can be killed with direct herbicide spray. Unlike the submerged leaves, floating leaves have stomata on their upper leaf surfaces for exchanging carbon dioxide and oxygen. These stomata may also allow penetration of herbicides. Preliminary greenhouse studies have shown that herbicides such as Dalapon, simazine or glyphosate can control American pondweed when sprayed directly on the weed about 1 week after the ABA treatment or water stress. Anderson suggests that this system could be used in the field before canals are needed for irrigation.

The next phase of Anderson's research with USDA's Science and Education Administration is to determine minimum spray rates for effective control. He is also experimenting with 6 other growth regulators.

Of course more data must be collected before approval can be obtained from EPA and before any recommendations can be made. However all three herbicides are currently approved for other crop uses, and Dalapon is registered for use on irrigation canals.

TURF

FMC/Bolens-Jacobsen settle out of court

FMC Corporation, manufacturers of Bolens lawn and garden equipment, has reached an out-of-court settlement with Jacobsen Manufacturing Company, Inc., Racine, Wisconsin, in regard to a patent infringement suit initiated by FMC against Jacobsen last fall, according to Robert E. Bergen, division manager of FMC's Outdoor Power Equipment Division.

The suit, filed on November 18, 1977 by FMC was for damages, and to enjoin Jacobsen from infringing U.S. patent No. 3, 085, 386 which relates to a rotary lawn mower marketed by FMC under the Bolens Mulching Mower trademark.

In the terms of the settlement, FMC granted a license agreement to Jacobsen (for an undisclosed amount) covering the life of the Bolens Mulching Mower patent.

According to FMC, the patented Bolens Mulching Mower revolutionized the rotary lawn mower industry in the 1960's. The mower utilizes a special cutting chamber without a discharge chute along with a multi-pitched blade which cuts and then re-cuts the grass clippings, blowing them down into the lawn, thereby elminating the need for raking and bagging.

SOIL

Texas scientists study effects of iron oxide

Research is underway at Texas A&M University to develop ways to predict whether certain soil management practices, such as liming or heavy fertilization, will improve or hurt soil properties by changing the reaction of iron oxides. Scientists with The Texas Agricultural Experiment Station say that iron oxide min-

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Landscape Contractor News

Spec guide, maintenance report published

The second edition of the *ALCA Guide to Specifications for Interior Landscaping* has been released by the Associated Landscape Contractors of America (ALCA). The new 57-page manual represents a major expansion of the material contained in the original document. The manual contains four sections: an expanded introduction with a full explanation of the interior landscaping industry; a complete set of recommended bid preparation instructions; a complete recommended standard form of agreement; and a complete set of specifications of interior plants, including installation requirements and photographs.

The *ALCA Landscape Maintenance Report* is a 62-page report based in part on the proceedings of the Association's Maintenance Symposium held this past December in San Jose, Calif. It contains six papers originally presented at the meeting, including: "Tricks of the Maintenance Trade" by Herman Carruth; "Management Planning and Organization Development" by Rod Bailey; "Choosing the Right Herbicide for the Job" by David Hanson; "Marketing and Promoting Maintenance Services" by Roger Harris; "Cost Control and Financial Management" by E. Gray Payne; and "Problems to Avoid" by Douglas Hamilton.

Copies of either are available at $12.00 each ($5.00 to ALCA members) from: ALCA Publications, 1750 Old Meadow Rd., McLean, VA 22102.

Reward offered for theft information

The California Landscape & Irrigation Council, Inc., is offering a thousand dollar reward for information leading to the arrest and conviction of persons who steal, burglarize, or vandalize equipment and supplies belonging to contractors who are signatory to the Council's labor agreements.

The reward is jointly underwritten by CLIC and the Irrigation & Lawn Sprinkler Fitters Union, Local 345, and went into effect on Feb. 1. Large two-color posters and water-proof decals are being printed, and will be distributed to all landscape and irrigation contractors throughout Southern California who are signatory to the Council's labor agreements. Contractors will be encouraged to post the signs on their job sites and at their places of business, and to affix the decals on tools, equipment, and other items of value.

"Persons who become aware of theft, burglary, or vandalism should notify the company concerned, the local police, or the CLIC office," sais Ahlers. "Once a suspect is apprehended, arrested, and convicted, the reward will be paid in full to the informant with monies placed in a special fund for this purpose."

Container trees used in reclamation

Tree seedlings grown in small containers in a greenhouse can be used to revegetate land strip-mined for coal, according to Russell J. Hutnik and Edgar H. Palpant of the Agricultural Experiment Station at Pennsylvania State University.

One of the major advantages of this system, they claim, is that the container keeps the root system intact and protected in a fertile growing medium. In contrast, conventional nursery-grown tree seedlings are planted in a bare root condition and are subject to injury during processing for shipment.

For many years relatively large container-grown seedling trees were used in the high plains country of the West, to establish windbreaks where moisture was limited. These container-grown seedlings proved to be more vigorous than bare-root nursery stock and survival improved greatly.

According to recent studies at Penn State, however, the container-

Continues on page 94

erals such as geothite and hematite are widespread and abundant in many of our warm climate soils.

Iron oxides have a strong capacity to absorb anionic (negatively charged ions) plant nutrients such as phosphorus, nitrogen, sulfur, molybdenum, and boron. Such oxides also improve soil structure by binding clay particles into aggregates.

Seedbed quality, erodibility, and water infiltration are examples of soil properties likely to be influenced by this effect. Station scientists, studying the effects of iron oxide-clay bonding on soil properties, find there is an intimate physical association between silicate clays and iron oxides.

The ability of the mixture to buffer changes in soil acidity, often associated with high nitrogen fertilization, is influenced by reaction of iron compounds with surfaces of other soil particles. Future experiments on soil properties involving the reactivity of iron oxides will be designed to prevent essential soil management practices, such as liming or heavy fertilization, from damaging soil quality.

SEED

New bluegrass variety introduced by NAPB

North American Plant Breeders (NAPB) have introduced Enmundi Kentucky bluegrass, which it claims is the most disease resistant variety on the market. The variety is said to show good winter color, and with respect to adaptation, NAPB says Enmundi's cold hardiness extends its range throughout the American north, well into Canada. In the transition zone, southward, it has exhibited excellent heat and drought tolerance.

In Missouri turf trials, Enmundi performed within the top third at Columbia and in the state's southeast and southwest trials. The variety has done well in tests conducted by the University of California at a location half way between Los Angeles and San Diego. There, Enmundi's performance has ranked fourth or fifth among some 30 commercially-available bluegrass varieties tested during 1976 to 1978.

Enmundi showed the best resistance to Fusarium blight out of 89 Kentucky bluegrass varieties and blends evaluated in 1978 at Rutgers University in New Jersey, says NAPB. It suffered only 0.2% damage, while Fusarium levels of 15-25%

Continues on page 96

For ad on preceding page circle **125** on free information card

MANAGING TURFGRASS TRANSITION IN BOTH SPRING AND FALL

By George M. Kozelnicky, Assistant Professor of Turf Diseases and Genetics, Department of Plant Pathology & Plant Genetics, University of Georgia, Athens, Ga.

The term "transition" in turf parlance refers to the periods of time in which turfgrasses pass from one season to another and is usually reserved to describe warm-season grass management in those seasons south of the Mason-Dixon line.

Bermudagrasses, and other warm-season grasses, become dormant in the cold season. Dormancy implies life, not death. Dormancy is initiated by cool fall temperatures and is accelerated by frost. The degree of dormancy is dependent on the latitude of the region and the severity of the cold season. Such grasses growing in the latitude covering Virginia, Kentucky and westward become completely dormant in the winter. Those growing in southern Florida may not go dormant at all.

In between these extremes, the degree of dormancy fluctuates depending on temperatures obtained. During the wintering of 1976-1977 and 1977-1978 temperatures reached 0° F in many areas and grasses became completely dormant as far south as Macon, Ga. and Dallas, Tex. A completely dormant grass is one whose stems, stolons and leaves have been killed back but whose roots, rhizomes and crowns are alive. The length of the dormant season may be long (October-March) in the northern areas and short (December-February) in more southern areas.

Warm-season grasses pass through two transitions: fall, from growth to dormancy; and spring, from dormancy to growth. Grasses must be managed differently during each. In the fall transition, grasses must be managed to enter dormancy in a healthy condition. In the spring transition, they must be brought out of dormancy as quickly as feasible for their particular use.

Healthy root system reduces the vulnerability of bermudagrass to winter-kill.

Man and nature impose many conditions which may adversely affect the grasses while in dormancy, causing winter injury and preventing satisfactory re-appearance in the spring. Man usually has the greater impact. Some of the practices of man which adversely affect dormant turf are:

- non-relief of traffic-induced compaction
- permitting excessive thatch development
- unbalanced or excessive rates of fertilizer elements
- use of non-adapted cultivars
- non-correction of poor water drainage
- use of improper mowing heights
- over-irrigation
- allowing shade on critical turf areas
- misuse of pesticides

Nature capriciously adds to the effect with:

- dessication by high velocity, drying winds
- low temperatures of varying lengths of time
- snow and/or ice cover
- disease

These factors, and combinations of them, are capable of killing bermudagrasses during the dormant period. The resulting condition is commonly called winter-kill and can occur on swards in golf greens, tees, roughs and fairways, as well as in other important turf areas.

Fall Transition

Management for fall transition should begin (if it has a point of origin) in the summertime. The grass should be maintained in a healthy condition and at a reasonable rate of growth. Cultivation procedures, such as aerification, should be performed early enough to allow the grass to recuperate before the onset of conditions which will start retarding the grass. Excessive plant nutrients that are conducive to lush growth should be avoided. Nutrients should be applied only as indicated by soil tests. In order to pass through dormancy safely, grasses should have a healthy, deep root system.

Carbohydrates provide the elements for initiation of new growth from crown adventitious tissue in the spring. Because roots are the primary storage organ for carbohydrates, late summer nutrition should include adequate amounts of those nutrients which encourage good root development. Expecially important is potash and in those areas where they are lacking, phosphorus and sulfur.

Since carbohydrate reserves (and root populations) decrease when grasses are mowed, height of cut as temperature drops becomes important, needing to be raised or mowing frequencies altered. Removing too much top growth at one time results in root system reduction.

Managing turf for entrance into dormancy is complicated in many instances when warm-season swards are overseeded with cool-season grasses.

Two very different grasses must be simultaneously managed.

There are two major reasons for overseeding. Use of grass swards in the southern region is year-round, especially on golf courses. Putting is possible on a dormant bermudagrass green but color and uniformity of putting quality is a demand of southern golfers.

The second reason is because overseeded grasses do more than just provide color and putting quality. They provide active root growth which keeps the soil in a more friable condition than that provided by a dormant sod. Overseeded bermudagrass greens thus are able to take a good bit more punishment from traffic.

The growth of the overseeded grass must continue without being of detriment to the underlying bermudagrass. In some instances, the bermudagrass, in the early phases of dormancy, is inhibited by the application of a growth retardant. Generally, the culture of the sward is maintained in such a way as to protect the bermudagrass until it becomes sufficiently dormant and then management favors the overseeded grass.

Spring Transition

Bermudagrasses begin serious growth between 60-70° F (33-38° C). Once spring temperatures stabilize above 70, they grow rapidly. This occurs quite late in the spring. Growth can, and does, occur at lower temperatues but at a much slower rate. Unwanted stimulation, brought about by temperatures which initiate some response from the grass, can occur early in spring. The grass is thus subjected to alternating periods of growth and quiescence. If these are in sharp contrast to one another, winter injury may occur. It is essential not to unnecessarily stimulate the now awakening bermudagrass with nutrients. These should be applied when the alternating periods smooth out.

Growth of dormant grass is initiated by its crown cells developing both stem and root initials. The food which nurtures these initials comes, at first, from the old roots. As new stems and roots develop into mature organs, reserves in the old roots are depleted. They no longer function, except as solute conduits for a time, and eventually slough off to become part of the soil organic matter.

If nature and man have not disrupted normal biological processes, the changeover from old roots to new ones is smooth and transition is successful. Rarely, however, is an ideal transition obtained because of the aforementioned adverse conditions. It is best to discuss these as separate entities.

Compaction

It has been shown that the most important single factor contributing to death of grass in winter is compaction resulting from foot and vehicular traffic. Compaction kills grass because it prevents normal, necessary gaseous exchanges from occurring in the soil. (This is also true for grasses growing in heavy, fine-textured soils.) The necessary pore space for holding atmospheric oxygen is lacking and chemical reactions within the roots are impaired.

In late summer, the grass enters into dormancy damaged and is thus at a disadvantage and unable to withstand other adverse conditions. Carbohydrates are not stored in amounts needed for regeneration. The same conditions prevail in spring, when grass begins to emerge from dormancy.

Winter-kill indicates failure of bermudagrass to survive the dormant period of transition.

The process by which the grass plant uses oxygen to react with carbohydrates is called respiration. In an uncompacted soil, aerobic (with soil oxygen) respiration takes place. Energy, water and carbon dioxide gas are produced. In a compacted soil, respiration becomes anaerobic with less energy and greater amounts of carbon dioxide are produced. This quite toxic gas is trapped in compacted soil with resulting injury to the grass plant. In the anaerobic process, oxygen comes from stored carbohydrates and other substances within the roots. These are abnormal reactions and can only result in unhealthy or dead grass.

Cultural practices against compaction should be preventive. Traffic, both foot and vehicular, should be routed onto more tolerant areas and re-routed frequently. On high-use areas such as golf greens, cups must be moved frequently to protect the area around the hole.

In many places in the South temporary greens are established in the fairway near the permanent ones and no traffic is allowed on the latter. In some mid-South areas, mulches have been used on golf greens but the verdict on their success has not yet been rendered. In some few instances alternate greens or alternate areas on greens have been tried. Space restrictions and expense involved in erecting such greens limit their feasibility. Greens have been dyed with colorants for play but the disadvantage is that compaction is enhanced because there are no white roots, as with overseeding, to naturally relieve the effects of foot traffic. Certainly, turf areas shouldn't be used while they are exceedingly wet.

Coring, spooning, and other forms of aerification are effective cultural tools for relieving compaction. However, any such practice can be used only at the time it does the least damage to roots. As far as bermudagrass is concerned, aerification should be practiced early enough in summer for the root system to recuperate sufficiently and es-

tablish an underground system which will carry it safely through the dormant period.

Conversely, in the spring, aerification should not occur until the new grass has established itself sufficiently to withstand the loss of some roots. Any tool which harms the grass, even temporarily, should never be used when it is doubtful that the grass will recover in time to enter a stress period. Any factor which allows or promotes compaction will encourage loss during dormancy.

Thatch

Thatch is an important component in turf swards but only when excessive. A certain amount is needed to maintain balance in the microbiological community in the soil. Excessive nutrition is one cause of excessive thatch.

Soil under heavy thatch is deficient in roots or rhizomes and is more easily compacted because those plant parts are predominantly situated higher up in the thatch layer. When dry, heavy bermudagrass thatch sheds water and the soil under it becomes dry; but if wet, the thatch loses water rapidly because of evaporation.

It can readily be seen that roots and rhizomes situated in thatch are much more easily killed by low temperatures than those growing in mineral soil. Thatch, an organic medium, is also the site for pathogens which affect grasses. Since the microfloras of thatch and soil are not the same, these pathogens are not kept in balance and, given the right conditions, may parasitize plants. This relationship is discussed further under diseases.

One of the keys to thatch control is timely and judicious use of fertilizers. Excessive nitrogen results in lush growth. Bermudagrass will do well on no more than one pound of nitrogen per 1000 sq. ft. during the growing season.

Verticutting is essential, especially under higher fertilization.

Verticutting is essential, especially under higher fertilization. However, it should never be severe or deep. It should be frequent enough throughout the year to keep undesirable grass parts combed out. The use of the brush with the triplex riding mower has, unfortunately, been reduced. Brushing greens in advance of the mower will keep thatch at a minimum, reduce the need for frequent verticutting, and be less harmful to the grass.

Where thatch is very heavy, its complete removal at one time would be very detrimental. Such turf must be brought back slowly over a long period of time. Aerification is perhaps the best practice to employ in this case. This opens the thatch to air and water and allows regrowth around the aerifier holes. Topdressing should be coupled with aerification to ensure a more reliable comeback. Timing in the application of these procedures is of prime importance.

The emphasis here is that excessive thatch, among other things, leads to pathogenic problems. It, together with other factors considered in this treatise, is a prime contributor to many transition failures. Thatch control is essential to the subsequent control of turf diseases and to the production of satisfactory turf.

Turf Nutrition

It has been alluded to many times that unbalanced rates of fertilizer elements result in damage to grass. The damage comes from predisposition of the grass to the effects of adverse conditions. The most prevalent type of damage comes from lushness promoted by excess nitrogen, but there are others.

Minor elements need to be considered, chief of which may be sulfur.

Deficiencies are equally as important. Low potassium will not allow hardening of grass tissues so that they may withstand rigorous conditions. Minor elements need to be considered as well, chief of which may be sulfur.

How does one know what he does or doesn't need? The use of a soil test! Turf managers should submit soils for testing, ideally, once a year. The timely use of all fertilizer elements at the correct rates is essential for grass which withstands adversity.

The standard soil test provides a reading of soil pH. Fertilizers frequently change the soil pH over a period of time. It is essential that pH be maintained at the proper level for the grass being grown.

Calcium and magnesium are necessary minor elements in turf culture and must be maintained in the correct relationship to one another. These elements are supplied, and pH is corrected, by dolomitic limestone. This substance does not immediately alter pH but takes considerable time to be broken down. One must, therefore, be aware of the entire soil situation well enough ahead of time for correction so that bermudagrass will not be at a disadvantage as it enters dormancy.

Cultivars

Bermudagrass varieties, hybrids, and cultivars of many different kinds are used throughout the region in which we are considering transition. They do not react similarly to conditions and each requires its own form of management. The importance of this can be seen in the change in use of grasses which has come about in recent years. Zoysiagrass has replaced certain bermudagrasses on fairways and tees in the Kentucky-Missouri-Kansas region. Throughout the upper South bermudagrass greens have been replaced in many places with those of creeping bentgrass because of the former's susceptibility to spring dead spot of bermudagrass (SDS).

Continues on page 22

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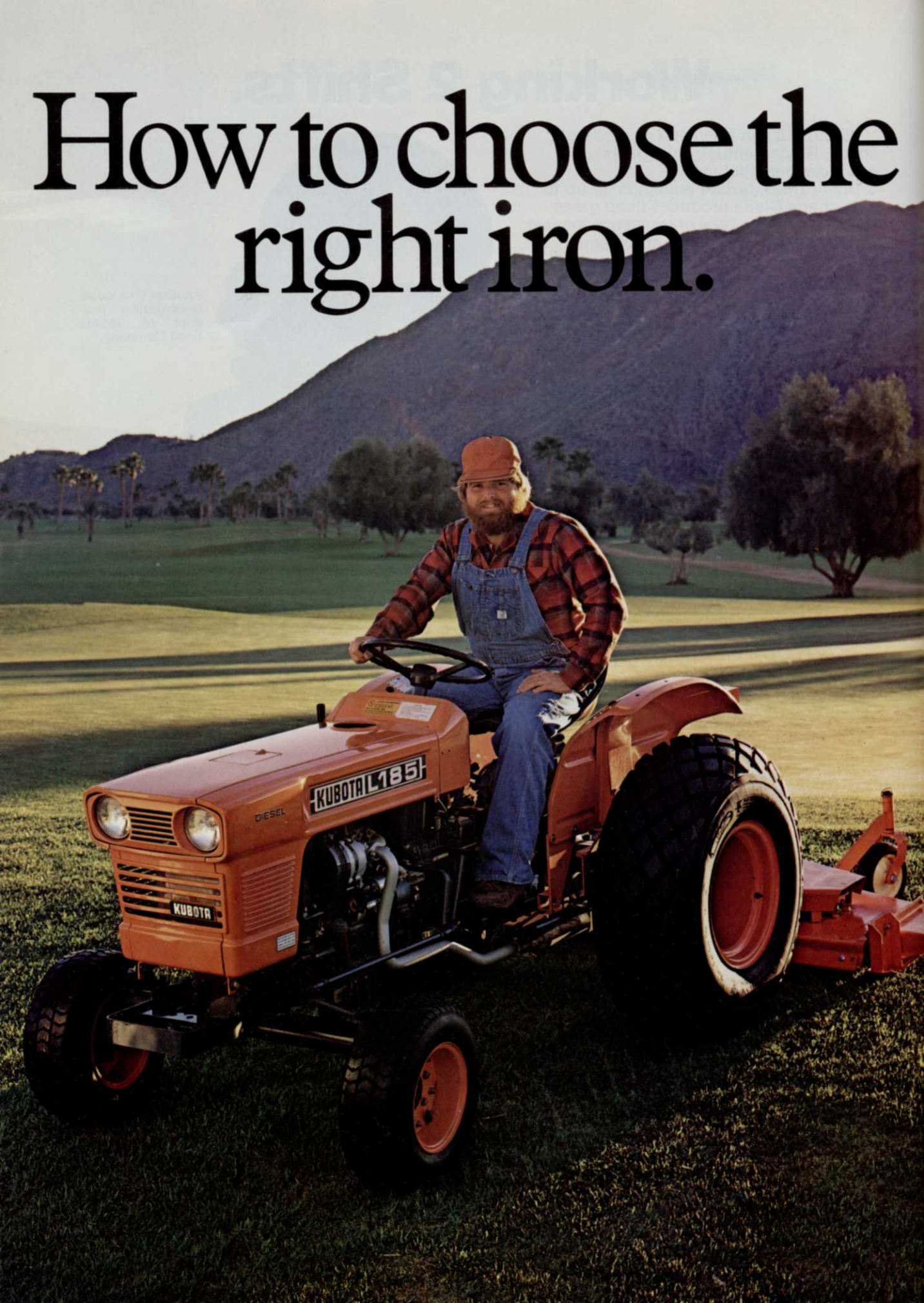

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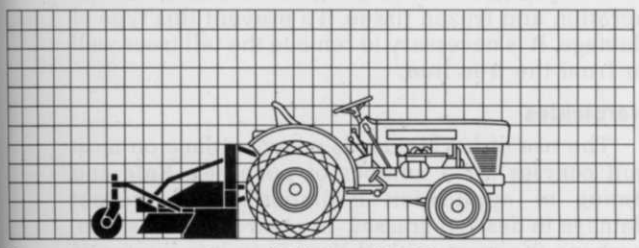

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Much has yet to be done in breeding better bermudagrasses in spite of the excellent work that is going on, especially in regard to winter hardiness. Present ones perform well in most years, if managed properly. Any bermudagrass should not, however, be grown at the outer edge of its range of adaptation. New grasses should be tested on location instead of arbitrarily deciding to use them.

For a number of years now, golf course superintendents in the Tennessee and north Georgia area have been critically examining Midiron (P-16) for its ability to overcome winter effects on their regular cultivars. Most seem to be pleased. Still they want more time to evaluate it. Some work at universities in the region shows this grass to perform well.

All bermudagrasses may suffer winter injury to some degree.

The same work indicates that all bermudagrasses may suffer winter injury to some degree. The best ones appear to be Tifway (419) and U-3 with Tifgreen (328). Tifdwarf and Tufcote are seemingly susceptible. Common bermudagrasses may suffer damage at times but, because of genetic diversity, performance in any one year is unpredictable. Commons selected within a region appear to tolerate winter injury a little better than other commons.

Choice of cultivars is especially important in the establishment of a turf. Spriggings and seedings that are able to withstand a severe first winter will have little difficulty in subsequent winters.

Drainage

Soils which retain water too long, especially in localized low spots, provide conditions which lead to loss of grass. The foremost condition is prevention of gaseous exchange of both oxygen and carbon dioxide, reducing transpiration and bringing about death of roots. Areas of little or no drainage are subject to prolonged freezing which brings about the same results. Too, these areas are prone to be compacted more easily by traffic. Providing drains for excess water to move out is essential to turfgrass survival in these areas.

Mowing

Turfgrasses are prevented from establishing as deep a root system as their counterparts used in forage and pasture by the kind of management applied. When a plant is fed it grows and produces leaves, stems and roots. Almost immediately, in turf management, the new top growth is removed by mowing which reduces the photosynthetic area needed for regrowth. When growth occurs again, it is primarily top growth. And again we cut it off!

Eventually, there is not much of a root system because its priority is below that of the leaves. With such a deficient root system the grass is in trouble in the winter. Raising the height of cut and reducing mowing frequency will do much to regenerate root growth. Generally, the higher the cutting height, the better the root system. The objective of mowing is not just to cut grass but to manage it in such a way as to strike a balance between roots and leaves and at the same time provide a suitable surface for a particular use.

Irrigation

Irrigation is both a boon and a detriment. When misused, it makes the work of the turf manager very difficult. Any system, that applies enough water to consistently run off the surface or to pass through the soil medium into drains, is applying too much water and courting trouble. Fertilizer is probably being leached and made unavailable to the turf. Secondly, roots are not stimulated to reach down into the soil and are usually situated within the top inch. Under these circumstances, loss of irrigation water would be catastrophic to the turf.

Thirdly, water-saturated soil is the same type of soil medium that compacted soil is. Such soil is also much more easily compacted. Atmospheric oxygen becomes unavailable and carbon dioxide becomes toxic. Lastly, this condition provides an excellent growing medium for water-loving fungi like the Pythiums which can further debilitate a root system.

Throughout the year, all factors considered, it is best to apply water only when it is needed by the plant almost to field capacity and then wait until the amount is depleted. Only then is the soil recharged. This type of application may be impractical to program into a system but shouldn't be any harder than syringing cycles.

Shade

Bermudagrasses react adversely to the slightest bit of shade. The deeper the shade, the poorer the bermudagrass with potential natural replacement by shade-tolerant grasses. Winter shade becomes of importance in turf survival because of the long shadows cast by trees, especially tall pine species. Turf shaded in this way may remain frozen much too long.

Many golf fairways situated along streams are shaded in this manner and have to be renovated each spring. It is not uncommon in the South for this condition to last from late November to late February. The result is no bermudagrass emerging in the spring. Death of the grass is due to lack of aeration and frozen tissue. To prevent this type of damage, it is necessary to remove the tall trees well in from the tree line.

Herbicides

The use of herbicides is commonplace on most golf courses for a number of purposes. Rate and timing of application is important to prevent damage to desired grasses. In regards to transition, perhaps the most critical time is in late winter or very early spring when paraquat and glyphosate are used to eliminate broadleaves, *Poa annua*, and other green species from fairways and tees and other turfs. If bermudagrass has been aroused and is growing in the slightest degree, the application of these non-selective herbicides will retard it and prevent a normal transition. The bermudagrass

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Winter-kill can lose a good customer if the phenomena is not carefully explained.

must remain completely dormant in this instance. The application of herbicides to turf that is making some growth is flirting with a replanting job. In spring renovation due to winter kill, it has been found that application of herbicides may delay the establishment of a satisfactory turf. This may predispose the turf to damage in the next winter.

The use of preemergence herbicides on golf greens is a similar situation. Post-emergents should never be used at higher rates in early spring as the bermudagrass is emerging from dormancy. Know the state and condition of your summer grass and apply herbicides only when it is safe to do so and the time and dose is right!

NATURAL PHENOMENA

There is nothing that man can do about what Mother Nature does. He can however, anticipate and prepare for what she does.

Dessication

At times, under low humidity, high velocity winds may occur during the dormant season. Dessication of this nature is more serious on green grasses, but there is an effect on dormant grass as well, even though indirect. Excessive transpiration depletes the soil of water and it must be replaced, especially on overseeded greens. Dry spots are damaging to dormant turf if allowed to remain.

Temperature

The effect of temperature on dormant grasses lies in the sharp contrasts that occasionally occur between these. A sharp drop to very low temperatures after a period of warmth which has stimulated dormant grass will result in retardation, at best. The earlier in the fall and later in the spring these contrasts occur, the more damaging to the grass. The damage is first invisible but becomes manifest in the spring because damaged cells cannot function.

Play or traffic on frozen turf must not be allowed! Frosts, and temperatures which fall below 32° F (0° C), cause ice crystals to form within the cells of all grass tisssues. When pressure by any form of traffic is applied to these cells, they are injured and will die. Where the soil water is frozen in a turf it must be allowed to thaw **completely** before traffic is permitted on it. Otherwise, devastating damage to roots by shearing occurs at the interface between frozen and unfrozen soil.

Snow/Ice

Winter precipitation which lingers too long as a cover is rare in the bermudagrass region. Its effect, if it persists, is the prevention of gaseous exchange in the soil and the enhancement of disease (snow molds) with resultant loss of both dormant and green grasses. The condition, if and when it occurs and persists, must be alleviated.

Diseases

Generally, diseases are not problems on dormant bermudagrass. They do, however, affect this grass prior to and after dormancy.

The Helminthosporiums, which affect leaves, crowns and roots and are perpetual inhabitants of soil and thatch, are especially active in late summer and fall and have a direct effect on entrance of grass into dormancy. Their control should be by a year-round preventive fungicidal-cultural program.

The snow molds are rarely a problem in bermudagrass even though the causal agents (especially of pink snow mold) are omnipresent in our soils and thatch and are seen growing saprophytically on dormant turf. There is not a snow cover of enough duration.

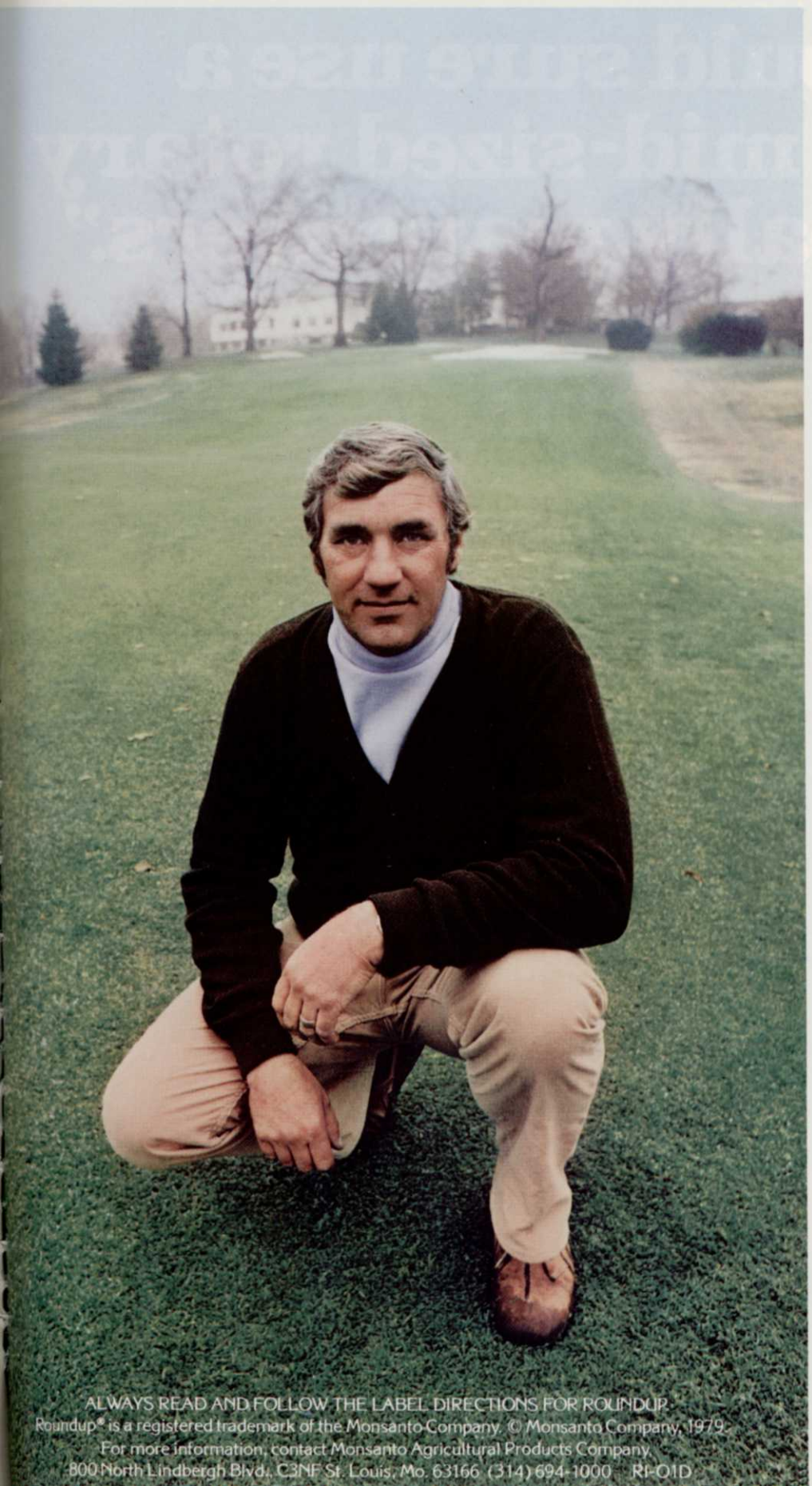
Perhaps the most important disease of dormant bermudagrass if the root rot named spring dead spot of bermudagrass(SDS). The disease is so named because straw-colored spots ranging from a few inches to a foot in diameter remain as the grass becomes green in the spring. These spots remain dead throughout the growing season and become green only because of encroachment by stolons from the periphery of the spot. The disease usually appears the third year after establishment on turf that has been fertilized heavily and which has heavy thatch. It affects all cultivars to some degree and has been investigated since 1954. To date no causal agent has been identified.

Good evidence indicates that this is a "management disease" which can be controlled by sensible turf management. Enough is not yet known to recommend fungicides for control; these have been tested but their general use would be overly expensive at the present time.

There is a mistaken notion that this disease is a form of winter-kill. Evidence shows that this is not so; it predominantly favors pathogenic action.

In summary, providing a suitable bermudagrass turf on all areas from one summer to the next lies in the best turf management procedures it is possible to apply, and requires knowlege and use of the basic principles of turfgrass science. **WTT**

How Roundup® helped Jim Siegfried renovate this fairway in days, without closing it for one minute.



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Last fall, Jim Siegfried found a way to clean it up, without tearing it up—at the height of his club's busy season. With Roundup® herbicide by Monsanto.

Jim is the Greens Superintendent at Losantiville Country Club, Cincinnati, where bermudagrass had become a serious problem on the 18th fairway. To control it, Jim applied Roundup once—while the weeds were still actively growing—right at the start of the Labor Day weekend.

"That's really 'prime time' here," Jim told us. "But after we applied Roundup, we kept the fairway in play the whole weekend, and after. The members played right over it, with no problem."

Since Roundup has no residual soil activity, and won't wash or leach out of treated areas to injure desirable plants, Jim simply took normal precautions against spray drift—and didn't worry about damaging desirable vegetation along the fairway.

Even better, he was able to reseed right into the dying bermudagrass only 7 days after applying Roundup—without loss of playing time or inconvenience to the membership.

Reinfestation won't be a big problem for Jim, either. He knows that Roundup destroyed the rhizomes of the treated weeds, helping prevent their regrowth.

Jim thinks he'll use Roundup again this year—and apparently some club members hope so, too. "As soon as they saw how good this fairway looks, some of the members started asking when I'm going to do the same for #10, where we have some more bermuda. I'll probably tackle that with Roundup this fall."

If controlling many tough emerged weeds and grasses is a problem for you, see your local Monsanto representative or chemical dealer soon for your supply of Roundup.

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GEOCHEMICAL FACTORS AFFECTING PLANT GROWTH IN RECLAMATION

W. Clark Ashby, William C. Hood, and Mary L. Guerke

Reclamation under the strict requirements of the federal Surface Mining Control and Reclamation Act of 1977 requires a high level of knowledge of plant growth requirements in relation to geochemical factors on each mine site. A desirable reclamation goal would be to consider all feasible alternatives for creating productive soils and attractive landscapes. The raw materials for achieving such a goal are the rocks and unconsolidated overburden that are commonly termed spoil after mining. Misdirected reclamation tasks can introduce unnecessary costs, lessen success of revegetation, and deny opportunities for building a land better than before mining.

In this paper we focus on the geochemical processes, to which the various minerals contribute on an uneven scale. Sulphur-containing rocks and minerals dominate the geochemical processes. We do not evaluate the highly important role of soil physical conditions in reclamation.

In many respects the soil-plant relationships on mine spoils can be understood as an extension of knowledge from traditional agricultural studies. Agricultural soils are, however, composed for the most part of materials which have been exposed to weathering processes for thousands of years. They typically are leached and ion-poor. Mine spoils contain large amounts of minerals freshly exposed to weathering; these minerals may release large quantities of ions. Spoils underlying topsoil are subject to these same oxidative weathering processes, although probably at slower rates. Spoil thus differs from other midwestern soils in that it involves an ion-rich environment.

Geochemical knowledge is vital to solving complex reclamation problems.

The Geological — Overburden is the general term that is applied to all the materials that lie between the earth's surface and a coal bed. A very large variety of materials can exist as overburden. These range from solid rocks such as shale, limestone and sandstone through various unconsolidated surficial materials of diverse origin, such as sediments deposited by streams, lakes, glaciers and wind. Soils can be developed on any of these materials.

Certain minerals or groups of minerals are common in all of these assorted earth materials. The clay minerals make up most of the fine-grained rocks such as shale and mudstone and are common in limestones, siltstones and some sandstones. They are equally abundant in fine-grained unconsolidated sediments and are important constituents of soils.

Quartz is the most important mineral in the coarser sediments and rocks, such as sand and sandstone, and is very common in nearly all other types of overburden rocks. The mineral calcite is the chief constituent of limestone and is common in shales and as a cementing agent in sandstones and surficial materials. Lesser amounts of the minerals feldspar, mica, dolomite and siderite are frequently found. Manganese and iron oxide coatings frequently act as cements to hold grains together.

Although generally minor in amount, sulfide minerals such as pyrite, marcasite and sphalerite are quite important in the geochemistry of weathering of overburden materials. Indeed iron sulfide, pyrite (or occasionally marcasite), is the main geochemically active mineral in overburden materials and any portion of the overburden that contains this mineral may give rise to conditions that affect plants. Because surficial materials have frequently been through one or more episodes of oxidative weathering, they are generally devoid of such minerals. On the other hand, the ancient sedimentary rocks may contain appreciable quantities of sulfide minerals and may cause major

The authors are respectively Professor, Department of Botany; Professor, Department of Geology; and former Graduate Assistant, Department of Botany. This research was supported in part by funds provided by the USDA Forest Service Northeastern Forest Experiment Station, Research Work Unit NE-1605, and by the Southern Illinois University Coal Extraction and Utilization Research Center. We thank Clay A. Kolar for contributions.

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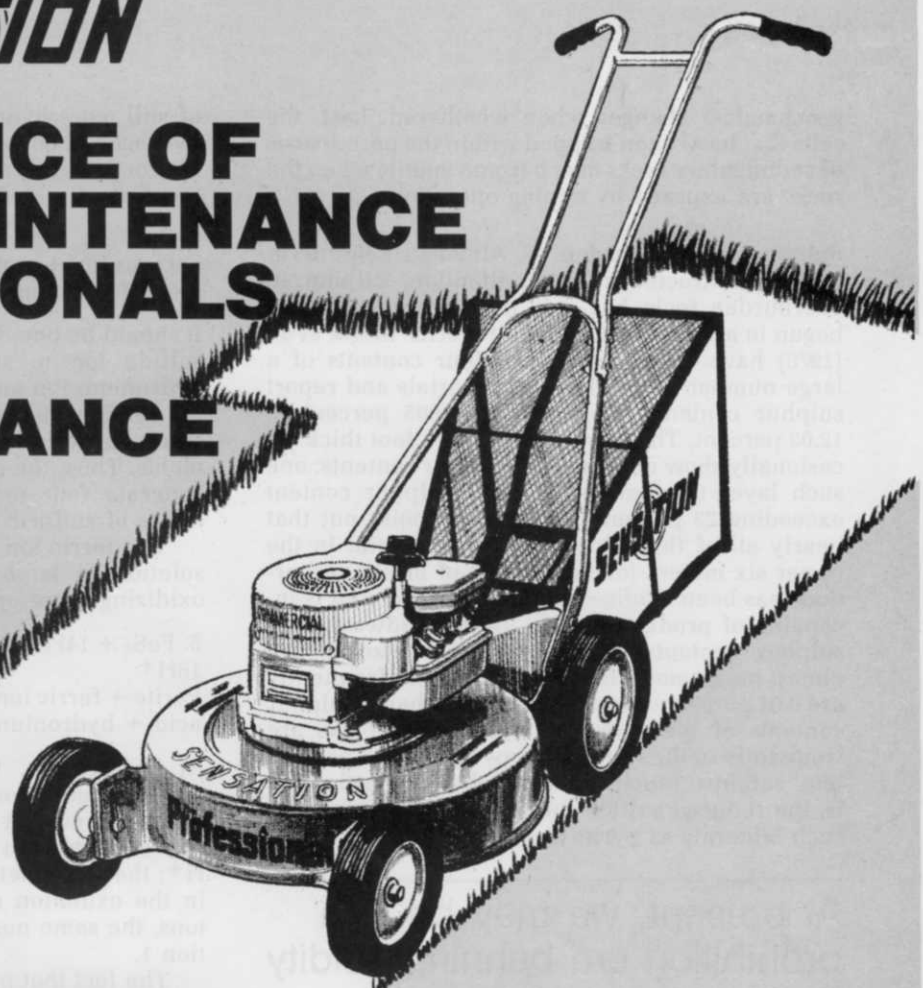

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geochemical changes when weathered. Last, the salts that have been trapped within the pore spaces of sedimentary rocks may become mobile when the rocks are exposed by mining operations.

Sulphur in Overburden — Although sulphur in coal has attracted a lot of attention, sulphur in overburden rocks has only in the past few years begun to attract the attention it merits. Smith *et al.* (1976) have examined the sulphur contents of a large number of overburden materials and report sulphur contents ranging from 0.005 percent to 12.03 percent. Thin layers less than a foot thick occasionally show much higher sulphur contents; one such layer 0.3 foot thick had a sulphur content exceeding 22 percent. Smith *et al.* point out that nearly all of the sulphur-bearing material in the upper six meters (about 20 feet) of most overburdens has been oxidized and neutralized, and is incapable of producing acids. In the Midwest, total sulphur contents of such weathered zones are almost never more than 0.1 percent and frequently are 0.01 percent or less. On the other hand, sulphur contents of unweathered sedimentary rocks are frequently in the range of a few tenths of a percent total sulphur. Much of this sulphur is pyritic, that is, the reduced sulfide form of sulphur present in such minerals as pyrite and marcasite.

At present, we may be in a prohibition era banning acidity by liming or other means because we do not have enough understanding of other indirect factors limiting plant growth.

It is well known that the oxidation of pyrite and related minerals generates acid mine drainage. Some of the oxidation reactions that have been proposed are:

1. $FeS_2 + 7/2\ O_2 + H_2O = Fe^{++} + 2SO_4^{=} + 2H^+$
Pyrite + oxygen gas + water = iron + sulfate + hydronium ions
2. $Fe^{++} + \frac{1}{4}\ O_2 + H^+ = Fe^{+++} + \frac{1}{2}\ H_2O$
Ferrous ion + oxygen gas + hydronium ions = ferric ion + water
3. $Fe^{+++} + 3H_2O = Fe(OH) + 3H^+$
Ferric ion + water = ferric hydroxide + hydronium ions

Equation 1 shows how one mole of pyrite can be oxidized in the presence of water and oxygen to liberate ferrous ions, sulfate and two moles of hydronium ion. Equation 2 illustrates the further oxidation of ferrous to ferric iron, and equation 3 shows how ferric ions hydrolyze to give a precipitate of ferric hydroxide with the liberation of still more hydronium ion. Equation 2, in which hydrogen is consumed, can be combined with the hydronium-liberating equation 3 to give the overall reaction:

4. $Fe^{++} + 5/2\ H_2O + \frac{1}{4}\ O_2 = Fe(OH)_3 + 2H^+$
Ferrous ion + water + oxygen gas= ferric hydroxide + hydronium ions

It should be noted that the original oxidation of the sulfide ion to sulfate generates two moles of hydronium ion and the oxidation of ferrous ion to the ferric state, coupled with the precipitation of ferric hydroxide, generates an additional two moles. Thus, the complete oxidation of pyrite will generate four moles of hydronium ion, or two moles of sulfuric acid.

The ferric ion, although not usually present in solution in large amounts, can act as a strong oxidizing agent on pyrite. The equation is:

5. $FeS_2 + 14Fe^{+++} + 8H_2O = 15Fe^{++} + 2SO_4^{=} + 16H^+$
Pyrite + ferric ion + water = ferrous ion + sulfuric acid + hydronium ions

At first glance, this equation would appear to release much more acidity than the earlier equations. However, it must be realized that the generation of each mole of Fe^{+++} requires one mole of H^+; there is a net gain of two moles of hydronium in the oxidation of pyrite to ferrous and sulfate ions, the same number as were liberated in equation 1.

The fact that pyritic sulphur is present in overburden rocks is not in itself bad nor does it in itself mean the overburden will become acidic or toxic to plant life. The form of the pyrite is an important determinant in the rate at which the pyrite oxidizes and the rate at which acid is generated (Caruccio 1970, 1975). Smith *et al.* (1976) carefully point out that the balance between the acidity potential and the neutralization potential is an important factor in determining whether minespoil becomes acidic when weathered. Present regulations require the burial of rock which contains highly reactive forms of pyritic material in quantities exceeding the ability of the minespoil to neutralize the acid. Not quite so obvious is the situation where the upper portion of a minespoil contains reactive pyrite and an abundance of neutralization materials. This situation can create environments especially rich in ions and salts, which may be stressful to plants as discussed in a later section.

Effects of Acidity on Plant Growth — *Neither the best methods for the determination of soil acidity nor its interpretation in terms of soil chemistry and the effects of acidity on plant growth are agreed upon and well understood.* Most plants in the eastern United States probably grow best from pH 5.6 to 6.5, medium to slightly acid soils.

Plant physiologists agree that only below pH 3 (greater than 0.001 molar hydronium ion) are plants harmed directly by acidity itself (Arnon and Johnson 1942). Indirect effects, such as the liberation and mobilization of toxic elements, also may severely limit growth below pH 3. These indirect

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effects are the cause of limited growth under acid conditions above pH 3.

Many authors list pH 4, and others pH 4.5, as a lower limit for reclamation plantings. They are right only if the spoils have an ionic composition which results in one or, more likely, a number of toxic conditions. *Under the right geochemical conditions plants grow very well at pH levels typically measured on barren spoils.* For example, spoil banks in Saline County, Illinois, which averaged pH 3.4, much lower than the pH of many "toxic" banks, were planted to 17 tree species in 1947. After 30 years those plots had a vigorous young forest with strong invasion of oaks and other species. Sweet gum trees averaged 9.3 inches in diameter and were larger than the trees on the other 12 plots of this study in Illinois, all of which were at higher pH (Ashby *et al.* 1978).

Chemical tests are widely used guides for revegetation management, and pH is the best test we now have. Unfortunately our understanding of the role of acidity in reclamation practice is much like that of alcohol in society. Alcohol is generally believed not to be harmful of itself, but it leaves a legacy of derelict individuals, broken homes, health problems, shortened life spans and deaths on the highway. Acidity is widely regarded as undesirable. At present we may be in a prohibition era, banning acidity by liming or other means because we do not have enough understanding to work out which of its numerous indirect effects limit plant growth and could be corrected in other ways.

Direct Effects of Pyrite Oxidation — There are four direct effects of pyrite oxidation. First, the oxidation reactions liberate quantities of hydronium ion in proportion to the amount of pyrite undergoing oxidation (reactions 1-4). If there are insufficient quantities of neutralizing materials in contact with the pyrite to counteract it, the obvious effect of the hydronium ion is to lower the pH of the area in which the pyrite is undergoing oxidation. In such a situation, the liberated acid may spread the products of the oxidizing pyrite beyond the spoil through surface and ground water and may be felt many miles downstream.

The second effect is the liberation of ferrous ion. If the oxidation potential and/or the pH of the environment is low, the oxidation of ferrous to ferric ion is slow and large quantities of iron may be mobilized. Seeps emerging from pyritic spoil materials frequently contain hundreds to thousands of mg/1 of iron. Since the seeps are simply ground water that flows onto the surface, similar concentrations of ion may be available in the rooting environment. *Continues on page 36*

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The third direct effect is the liberation of sulfate ion. Again, concentrations of thousands of mg/l of sulfate are reported in seeps from acidic spoil materials. Hundreds to a few thousand mg/l of sulfate can be found in seeps and streams draining non-acidic, but nevertheless pyritic, spoil material. Similar concentrations can be expected in the ground water and soil solutions. A recent study by Hood and Hood (in press) suggests that typical sulfate yields of minespoil in the southern Illinois area are on the order of 4.1 kg/hectare/day which would mean about one-half ton of sulfate per year is generated and leached from each acre of minespoil under the climatic conditions of that area. If most of the oxidation of pyrite takes place in the upper few inches of the minespiol, there should be an abundance of sulfate present in the near-surface environment. *The increasingly widespread recognition of sulphur deficiency under continuous intensive agriculture would not be a problem on soils created in mining.*

A fourth direct effect is the release of trace metals. Geologic materials are seldom completely pure, and pyrite is no exception. Many pyrite samples contain trace elements that are released as the pyrite oxidizes. Such elements include the micronutrients cobalt, copper, manganese and zinc as well as arsenic, antimony, cadmium, chromium, lead and nickel (Harper 1977, Blumthal 1977). Although present in small quantities in the pyrite, in places where oxidizing pyrite is abundant the concentrations of these elements in solution may become appreciable. In southern Illinois, however, trace elements released directly by the oxidation of pyrite generally account for less than ten percent of such elements in water (Harper 1977). The remainder are leached from associated overburden rocks.

Indirect Effects of Pyrite Oxidation — The sulphuric acid generated by the oxidation of pyrite is a powerful agent of chemical attack on overburden materials. These reactions take place within spoil micro-environments. The general result of such attack is the reduction of the hydronium ion concentration (elevation of pH) coupled with release of various soluble cations to the soil solution and ultimately, to the drainage waters.

Attack on carbonate rocks. Carbonate rocks, such as limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$), are susceptible to attack through reactions such as:

$$H_2SO_4 + CaCO_3 = Ca^{++} + SO_4^{=} + H_2O + CO_2$$

The reaction for dolomite is similar, albeit slower, and liberates magnesium as well as calcium. The effectiveness of this means of neutralization of acid is, of course, dependent on the availability of the carbonate minerals, whether as discrete rock

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units or as accessory minerals in other overburden rocks. The concentration of these ions in the soil solution can become large. They affect the calcium-to-magnesium and other ratios of calcium, magnesium and potassium which are of importance in plant growth.

Using southern Illinois as an example, it has been established that there is nearly a 1:1 relation between sulfate and hardness in stream water (Hood 1977). This relationship is little affected by pH. Hardness, reported as $CaCO_3$, is a measure of Ca + Mg and can be approximated as Ca. If sulfate is 1000 mg/l, hardness would also be about 1000 mg/l and Ca and Mg approximately 400 mg/l. *Runoff waters from coal mines frequently contain on the order of 1000 ppm sulfate or more, so calcium and magnesium are abundant in soil water. These runoff waters supplied by irrigation to soils locally deficient in sulphur or magnesium can be expected to increase plant growth.*

Attack on shale. Shale is one of the most common overburden materials. Acids generated through oxidative weathering of pyrite can attack shale in a variety of ways. In the simplest fashion, there can be an ion-for-ion exchange of hydronium ions from solution for exchangeable ions of the clay minerals. This can release nutrient ions which subsequently may enhance plant growth, or be lost in runoff or percolation waters. The clays then become hydrogen clays, which makes the removal of any remaining nutrient ions by plant rootlets very ineffective.

A high aluminum concentration is the most common cause of failure of agriculture crops on acid spoil.

It is well known that clays affected by acidity can convert to aluminum clays, with aluminum migrating out of the clay structure and onto cation exchange sites. In this situation, the hydronium ion is attacking the interior of clay, liberating aluminum which migrates to the clay surface and becomes fixed, reducing the effectiveness of the clay as an ion exchange substrate for supplying nutrients to plants. Aluminum in the soil renders phosphorus unavailable by forming aluminum phosphates. Russell (1973) states,

"A high aluminum ion concentration is the most common cause of failure of agricultural crops on acid spoil. It probably has two quite distinct effects. A high aluminum concentration in the free space of the root surface may prevent the root taking up phosphate, and aluminum inside the living cell may interfere with sugar phosphorylations."

Identification of aluminum toxicity is difficult because clear-cut visual symptoms are lacking. Plant yields can be depressed, leaves show a purplish coloration, and roots usually are stunted but there are exceptions. These relationships are most likely to be found on acidic mine spoils.

Problem spots like this are understandable and correctable with basic geochemical and soil knowledge.

Manganese oxides are common in shales, frequently making up a few tenths of a percent of the rock. In typical southern Illinois overburden rocks Hood and Stepusin (1975) found 0.05 percent manganese, of which about 60 percent is very readily dissolved in aqueous solutions of pH 2 and 3 formed in pyrite oxidation.

Although manganese toxicity is known for moderately well-drained agricultural soils below pH 5 (Manganese 1973) and is enhanced by acid soils with poor aeration, its occurrence on strip-mine spoils is difficult to determine. Changes in the ion balance of iron and manganese can lead to deficiencies or toxicities of either element. In view of the probable high levels of either iron or manganese on mined lands, attention to the balance of these ions is important. Foliar diagnoses of iron and manganese deficiencies or toxicities are confusing because of their similar appearances which include yellow or dead spots on leaves.

Coatings of iron and manganese oxides are rather common in earth materials. These coatings frequently act as sinks for various heavy metals. In association with oxidized pyrite these coatings can dissolve, releasing iron, manganese and the adsorbed trace elements such as cadmium, chromium, cobalt and nickel into solution.

Further relationships. Other minerals are locally abundant in overburden materials in the midwest. Sphalerite (ZnS) is one such mineral. It is

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present in fractures in coal, in siderite nodules, and in other ways in the overburden. This mineral is soluble in acids, and can also be oxidized by ferric ions in reactions similar to the oxidation of pyrite by ferric ions. Sphalerite frequently contains appreciable quantities of cadmium; thus oxidation and acid leaching of the sphalerite can release appreciable quantities of zinc and cadmium to aqueous solutions.

Nutrients found in minute or trace quantities in plants in addition to iron and manganese include boron, zinc, copper, molybdenum, cobalt (required for symbiotic nitrogen-fixing plants), and chlorine. In the past deficiencies and toxic levels of these and other trace elements were found on mines; however, these are not likely to be found under the regulations promulgated by the new federal Office of Surface Mining.

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Fertilization recommendations for reclaimed stripmines need to be tentative.

Fertilization recommendations for reclaimed stripmines need to be tentative, irrespective of whether the surface rooting medium consists of mixed overburden materials or of replaced soil. Recognition should be accorded and advantage taken of the mineral- and ion-rich environments which can be created from overburden materials underlying geologically impoverished soils on unmined land in many areas (Smith *et al.* 1976). Plant growth, or bioassay, will probably be a better means for assessing fertility relationships than chemical tests on selected nutrients.

Grandt and Lang (1958) analyzed 1,800 soil samples from 15 mining counties in Illinois. They found most of the samples to be very high in phosphorus and high in potassium. Test plots supported excellent growth of pasture.

Plots with 17 tree species each were established in 1947 by the USDA Forest Service on mined and unmined land in Randolph County, Illinois (Ashby *et al.* 1978). In 1976 the unmined plots were at pH 5.0 with extractable phosphorus (P) levels of 4 pounds and extractable potassium (K) of 144 pounds per acre. In contrast one set of mined plots with no previous management was at pH 7.2 with 9 pounds P and 354 pounds K and a

Grass grows in earthmover's tracks indicating the compacted earth was a better growing medium than the uncompacted on this site.

second set at pH 7.7 with 10 pounds P and 224 pounds K using the Bray acidified ammonium fluoride soil extraction method. Differences in P and K levels of the unmined and mined lands were even more marked using the Olsen sodium bicarbonate soil extraction method. Loblolly and shortleaf pine grew best on the unmined plots. These species are common on abandoned fields in the southeastern states. In contrast, black walnut grew much better on the mined plots. Soil which supports good black walnut growth is considered desirable for corn.

Until the properties of a newly-restored field are known, some nutritional requirements may go unrecognized. *A good way to find out the nutritional status of reclaimed land is to grow a select group of indicator plants which differ in their nutritional requirements.* An initial planting of mixed species for bioassay of the chemical environment on a mine site also serves to build organic matter, create root channels, and condition graded spoils for growth of later plantings.

Total Dissolved Solids — Stripmine soils and drainage waters commonly have high concentrations of total dissolved solids (TDS) resulting from direct and indirect effects of pyrite oxidation. Further TDS may be formed from neutralization of acidity with lime, fly ash, or other soil amendments.

Continues on page 61

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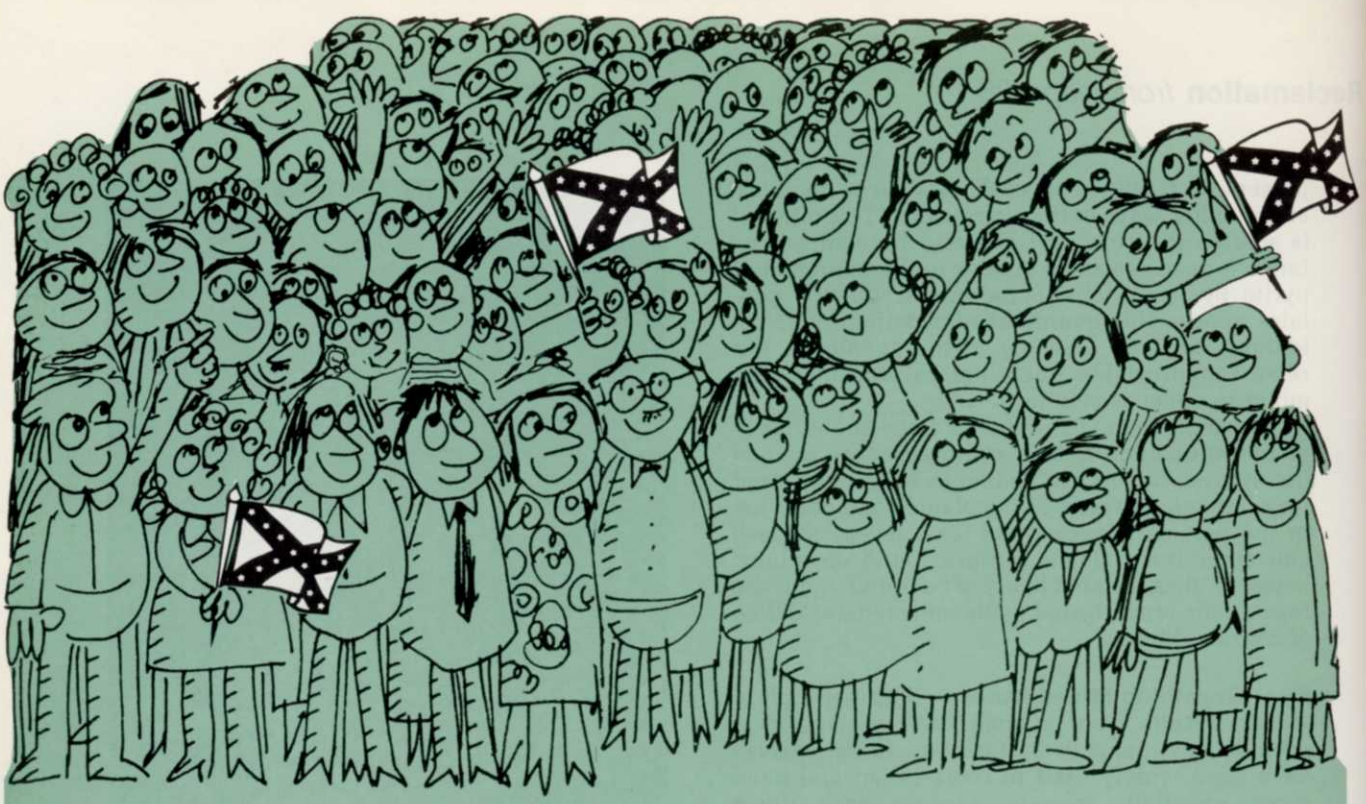

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Experts Discuss Latest On Thatch at Nebraska

Latest Thatch Information Is Helpful But Controversial

R. C. Shearman, Turfgrass Specialist, Department of Horticulture, University of Nebraska, Lincoln, Nebraska.

Thatch is a management problem on many turfgrass sites. The turfgrass manager is faced with maintaining turf on these areas under difficult and sometimes impossible conditions. In many cases, the turf manager is unaware of the integrated and complicated factors that are related to thatch accumulation and its influence on turfgrass stress and culture.

Considerable advances have been made in our knowledge about thatch during the past few years. We have learned new aspects about thatch, and its chemical and physical nature, causes, problems, benefits and prevention. Although considerable knowledge about thatch has been gained, more is needed and controversy exists over the knowledge we have gained so far. This is substantiated in the following articles included in this Symposium.

Thatch has been defined as "An intermingled organic layer of dead and living shoots, stems, and roots that develops between the zone of green vegetation and the soil surface." Careful examination of this definition indicates that emphasis is placed upon the intermingled layer of dead and living organic matter comprised of shoots, stems, and roots. In thinking this over, soil on a thatch-free, turfgrass site consists of living and dead organic matter comprised of shoots, and roots. The above definition of thatch therefore, is not entirely satisfactory. Thatch is a media located above the soil surface and is comprised of undecomposed and decomposed organic matter that is capable of supporting turfgrass plant growth. Mat is an additional term that adds confusion to the situation. Mat is not synonymous with thatch. Mat consists of a tightly intermingled layer of soil and decomposing organic matter. The added soil factor makes mat a more desirable growing media than thatch alone.

The chemical composition of thatch is mostly cellulose, hemicellulose, and lignin. Lignin is particularly prominent in the lower thatch where decomposition is more advanced. Turfgrass clippings contain very little lignin and decompose rapidly. As long as an adequate mowing frequency is maintained, clippings do not contribute significantly to thatch accumulation. Thatch may accumulate in intensively managed turfs such as creeping bentgrass or bermudagrass or it may accumulate in low maintenance turfs such as creeping red fescue or zoysiagrass. The cause of thatch accumulation, therefore, is not just the production of organic matter versus the rate of decomposition, but also the chemical composition of the plant materials comprising thatch.

The causes of thatch accumulation are equally as controversial as the definition of thatch. One can readily accept that if organic matter production exceeds the rate of decomposition then the net effect should be thatch accumulation. Factors that encourage organic matter production and discourage organic matter decomposition favor this accumulation. Cultural practices must be adjusted to avoid excessive organic matter production, and to provide an environment conducive to thatch decomposition. Earthworms and some insects are known to digest portions of the organic matter. They are important in relocating organic matter throughout the soil profile with their movement up and down in the soil. Certain pesticides reduce earthworm populations and induce thatch accumulation.

TABLE 1. Advantages and disadvantages of thatch in a turfgrass community.

Advantages (When present in moderate amounts):
1. Insulates the soil surface beneath the thatch layer
2. Reduces soil compaction
3. Increases the resiliency or cushioning effect of the turf
4. Increases turfgrass wear tolerance*

Disadvantages (When present in excessive amounts):
1. Increases turfgrass environmental stress
2. Reduces turfgrass tolerance to heat, cold, and drought
3. Increases disease incidence
4. Increases insect activity
5. Increases puffiness, scalping, footprinting, and spiking
6. Increases proneness to localized dry spots
7. Increases susceptibility to iron chlorosis
8. Reduces activity of certain pesticides
9. Increases phytotoxicity of certain pesticides

**Research at the University of Nebraska indicates that wear tolerance increases with thatch accumulation until a critical point is reached, when wear tolerance decreases.*

Contradictions also exist concerning the role of turfgrass cultivars, nitrogen, and mowing height in the accumulation of thatch. The turfgrass cultivar and mowing height may play a more important role in thatch accumulation then excessive nitrogen fertilization. Regardless of the cause of accumulation thatch is involved in beneficial and detrimental aspects in the turfgrass community (Table 1.). These factors are covered in detail in the subsequent articles.

In the past ten years we have gained considerably in our knowledge about thatch and its interaction with turfgrass culture and stress. As turfgrass managers we need to become more aware of the causes of thatch; its detrimental and beneficial aspects; its prevention; and perhaps most importantly, its modification to a more desirable growing media. The articles included in this Symposium will inform the reader of the present state of knowledge about thatch and will give the reader a better background for coping with this maintenance problem.

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Influence of Thatch on Soil Is Both Positive and Negative

A. J. Turgeon, Associate Professor of Turfgrass Science, University of Illinois, Urbana, Ill.

Thatch is a frequently observed phenomenon in turf. It is generated by the plant community and, in turn, influences turfgrass response to environmental conditions and cultural practices. Its presence in a turf is considered to contribute both positive and negative influences toward turfgrass persistence and quality. Much confusion exists over factors contributing to thatch formation and the impact of thatch in turf; therefore, this paper will attempt to provide insights into the significance of thatch and its derivatives as edaphic features in turfgrass ecosystems.

Thatch has been defined in various ways depending upon the perspective of the observer. Ledeboer and Skogley (1967) simply referred to it as an "excessive accumulation of undecomposed surface organic matter." Beard (1973) defined thatch as "a tightly intermingled layer of dead and living stems and roots that develops between the zone of green vegetation and the soil surface."

The principal difference between these representative definitions is the role of living plant organs in the composition of thatch. Upon examining the thatch from a bentgrass turf profile, Ledeboer and Skogley (1967) reported that live roots, crowns, and stolons were found along with sclerified fibers from supporting tissues, and other undecayed organic residues. Others have interpreted this to mean that thatch is actually composed of living and dead plant material; thus, the contemporary definition offered by Beard (1973), and supported by the Crop Science Society of America, provides this perspective.

Examination of the surface soil layer of a thatch-free turf would show that it, too, is composed of live roots and stems from the plant community growing in it; yet, soil is usually not characterized the way thatch is. Soil analyses are typically conducted with the live plant community removed even though root and subsurface shoot growth undoubtedly influence soil physical and chemical properties.

Separation of live and dead components of a thatch layer is more difficult, so it usually is not attempted. In fact, the growth of plant organs within the thatch clearly shows that thatch is not simply a surface mulch; rather, it is a surface medium supporting the plant community and, as such, is analogous in function to the surface layer of soil from a thatch-free turf.

In the author's view, thatch is most appropriately defined as a layer of residual biomass generated by the turfgrass community, situated above the soil surface, and constituting an important portion of the edaphic medium supporting turfgrass growth.

Thatch Formation

The exact mechanism of thatch formation is not clear. Typical explanations of this phenomenon cite an imbalance between primary production (plant growth) and decomposition of organic residues. Thus, any factor which stimulates growth rates beyond decomposition rates, or which depresses the decomposition rate below that of plant production, leads to the formation of thatch. Of course, organic residues at the soil surface are not thatch.

A stable thatch layer must be stabilized by the plant community; otherwise, it can quickly become fragmented and decomposed, especially during winter in cold climates. Turfgrass-induced stabilization of thatch can occur in several ways: crowns can form from emerging rhizome terminals once light is intercepted near the thatch surface, existing crowns can continue to develop upwards into the thatch, and adventitious roots, rhizomes, and stolons emerging from these crowns can grow in the organic debris to form an interlocking network of live material.

Research at the University of Illinois has shown that certain pesticides, which inhibit earthworm and microbial activities, can induce thatch on sites where it otherwise would not form (Turgeon, Freeborg and Bruce, 1975; Cole and Turgeon, 1978). The amount of thatch which develops, however, is influenced by the turfgrass genotype and cultural practices. In field tests with over 50 cultivars of Kentucky bluegrass, the range in thatch depth, three years after establishment, was between 0.7 (Park) and 2.0 cm (Touchdown). In a cultural study comparing seven cultivars, two mowing heights (0.75 and 1.5 inches), and four fertilization programs (2, 4, 6, and 8 lb N/1000 sq ft/yr), only cultivar and mowing variables were found to influence thatch depth; higher mowing generally resulted in more thatch while increased use of nitrogen had no significant effect. Since the lack of any differential response to nitrogen in this study is inconsistent with many reports in the literature, it would seem that other conditions would have to exist in order to predispose the turf to nitrogen-induced thatch formation.

Edaphic Characteristics of Thatch

Since thatch constitutes an important growth medium for turfgrasses, attempts should be made to characterize it in much the same way as is done with soil media. Based upon work conducted at the University of Illinois, Hurto (1978) reported that "clean" thatch is a highly porous medium with a predominence of large (aeration) pores; therefore, its water-retention capacity is low compared to a well-structured Flanagan silt loam soil.

The cation exchange capacity (CEC) of thatch samples has averaged approximately 50 milliequivalents per 100 grams (me/100g) which is substantially higher than that of a Flanagan silt loam. As long as different media have similar bulk densities, comparisons of CEC's provide indications of relative nutrient-retention capacities.

Lighter colored material just beneath grass is sometimes referred to as "pseudo-thatch".

Bulk density (BD) determinations with clean thatch samples have yielded very low values, usually less than 0.25 g/cc. Since plants grow in a given volume of a medium, rather than in a given weight, CEC comparisons should be made only after multiplying by BD as in the following example:

Thatch CEC @ 50 me/100g and BD @ 0.25 g/cc yields 12.5 me/100 cc

Soil CEC @ 30 me/100g and BD @ 1 g/cc yields 30 me/100 cc.

In this comparison, the volumetric CEC of soil is actually over twice as much as that of thatch. Given the low BD, the very porous nature of thatch and, consequently, the rapid percolation rate of water and dissolved nutrients through its profile, retention of cationic nutrients (NH_4+, Ca++, Mg++, K+, Fe++, etc.) by thatch would be low compared to many soils.

Another notable feature of thatch is its resiliency. With the application of a downward force, thatch compresses. Once that force is removed, the thatch springs back to its original state. Therefore, unlike many fine-textured soils, thatch resists compaction.

In summary, a thatch medium is well aerated and resistant to compaction, but is also characterized by poor nutrient- and water- retention capacities. When comparing the relative advantages and disadvantages of thatch to those of many fine- and medium-textured soils, it would be logical to conclude that an integrated medium, in which soil and thatch are blended together, would incorporate the desirable features of each component while compensating for various undesirable features. Integrated thatch-soil media will be discussed further under Thatch Control.

Influence of Thatch on Turfgrass Quality

Turfgrass quality is a function of genotypic and environmental conditions. Thatch, although reflecting in part some features of the turfgrass genotype, is an environmental (specifically, edaphic environment) feature in the turfgrass ecosystem. If a pure, coarse sand was used as the growth medium, sustaining the turf would require more frequent irrigation and fertilization than where a finer-textured soil were used. Thatch is, in some ways, analogous to coarse sand.

Field studies have shown that thatchy Kentucky bluegrass was more wilt prone, and had a higher irrigation requirement, under mid-summer stress than thatch-free turf in Flanagan silt loam (Turgeon, Freeborg and Bruce, 1975). Laboratory studies by Falkenstrom (1978) have shown that nitrogen retention by thatch is much less than in soil following applications of urea. This was due to rapid leaching of the nitrogen under moist conditions, and substantial volatilization of nitrogen as ammonia (NH_3) under dry conditions.

Other influences of thatch include higher disease incidence, reduced rooting, and lower water-infiltration capacities (Turgeon, Freeborg and Bruce, 1975). Jansen and Turgeon (1977) found that where water infiltration was lower in Kentucky bluegrass turf with a pesticide-induced thatch, the reduction was not due to the thatch layer but, rather, was associated with an altered physical condition of the underlying soil. Restriction of root and rhizome growth to the thatch layer and absence of earthworms in the underlying soil were factors accounting for higher soil bulk density, lower hydraulic conductivity, and reduced infiltration capacity in thatchy turf.

In herbicide studies, Hurto (1978) found that some preemergence herbicides were more phytotoxic when applied to thatchy than to thatch-free Kentucky bluegrass. He attributed this to greater downward mobility of the herbicides in thatch than in soil, and the inherent susceptibility of Kentucky bluegrass to herbicide injury when the herbicide is allowed to come into direct contact with the root system.

In a similar field study with non-selective herbicides for turf renovation, he found that paraquat residues in thatch were highly phytotoxic to overseeded perennial ryegrass. However, where soil was incorporated into the thatch or where the study was performed on a thatch-free site, little or no inhibition of ryegrass germination occurred from prior paraquat applications.

Thatch Control

Traditionally, thatch control has been synonymous with either mechanical removal, or topdressing (primarily greens) to favor decomposition. Results from recent and continuing research suggest that an alternative method should be considered. This involves thatch modification. A particular operation, or sequence of operations, which effectively blends soil and thatch into an integrated medium would almost immediately reduce many of the problems associated with thatch.

Although experience with topdressing greens has shown that soil inclusion favors decomposition of organic residues in thatch, this result is not immediate while many of the benefits of topdressing are apparent soon after the operation has been performed. On fairways in which core cultivation is practiced routinely, presumably to alleviate the effects of soil compaction, thatch is usually not a serious problem.

Again, soil inclusion in the thatch layer reduces thatch-associated problems and, eventually, favors thatch decomposition. In this case, soil from the

Relationship of Thatch to Disease and Insect Stress

B. G. Joyner, Plant Pathologist, ChemLawn Corporation.

Most turf will remain trouble-free the first few years after establishment. A few problems may occur, but diseases and insects are actually minimal those first few years, especially on home lawns. The length of time from establishment to the time when problems begin appearing varies depending on such factors as soils, turfgrass variety, maintenance and environmental conditions.

One factor generally associated with older established turfgrass is thatch, but this does not imply that turfgrass without a thatch problem is always disease and insect free. Thatch free turfgrass may also have disease and insect problems but not to the same extent. A turfgrass with a severe thatch accumulation will generally have more disease and insect associated problems.

The influence of thatch accumulation on disease and insect problems actually makes sense when the condition of turfgrass and factors involved with disease and insect problems are considered. Heavy thatch accumulation causes the turfgrass to grow under a stress situation most of the time.

Heavy thatch often results in many of the turfgrass crowns and roots growing in the thatch layer rather than in the soil. Because thatch does not have the moisture holding capacity that most soils do, turfgrasses growing in it are more prone to drought stress. Since the turfgrass crowns and roots are elevated in the thatch layer, the turfgrass also becomes less tolerant to temperature extremes and more prone to traffic stress. In addition, the turfgrass will have fewer roots into the soil to receive nutrients it requires to remain vigorous. Pesticides applied to a "thatchy" turf are generally rendered ineffective by the thatch.

Turfgrass in a weakened condition is more susceptible to disease and insect problems, while vigorously growing and healthy turf is better able to resist insect invasion or an attack by a disease causing organism. Healthy turfs can also tolerate higher populations of disease-causing organisms and insects without showing damage and recover from the damage more rapidly. Therefore, disease and insect problems occur when there is a susceptible host, a favorable environment, and a causal organism.

Host

The host, of course, would be the turfgrass. For an attack by a disease causing organism or insect to occur the host must be susceptible to that attack. Most turfgrasses are tolerant or resistant to a disease or insect problem to a certain extent but certain turfgrass species and varieties are more tolerant or resistant than others. This tolerance is minimized, if the turfgrass is in a stress condition, or if populations of the disease causing organisms or insects accumulate to damaging levels.

Thatch accumulations may be involved with both factors, of creating stress conditions and providing a place for disease causing organisms or insects to thrive.

Environmental Conditions

The resulting environmental conditions of heavy thatch is ideal for many disease causing organisms and insects. This thatch environment provides an excellent place for the turfgrass

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same system is cycled while, with topdressing, a foreign soil source is used. Core cultivation, then, can be regarded as a comparatively efficient procedure for cycling soil and converting thatch to an integrated medium which is no longer thatch, but a derivative similar to what Beard (1973) describes as mat.

Depending upon the thickness and density of the thatch layer, once over with a core cultivator may not be sufficient to convert thatch to a mat-like derivative. In some cases, it may be necessary to remove a portion of the thatch and open up the remainder via vertical mowing before proceeding with core cultivation. Each site will have to be examined and a suitable procedure determined. However, the objective is clear; only the method for accomplishing the objective is site dependent.

Evidence to date suggests that the results are highly beneficial. Reduced disease, improved water relations and aeration, reduced pesticide-induced phytotoxicity, and generally superior turf are obtainable where thatch modification, rather than removal, is practiced.

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crowns, stems, roots and even the foliage to be attacked. The moisture, humidity, nutrition, and temperature of the thatch layer make conditions more favorable for the growth of certain organisms, but not ideal for the growth of turfgrass. Therefore, disease and insect problems may occur more readily on thatch stressed plants.

Pest (or Pathogen)

The third factor involved in a disease or insect problem would be the presence of a disease causing organism or insect that is capable of inciting a problem. The thatch layer may provide an ideal place for the growth and reproduction of the pest, allowing pest population to increase to a damaging level.

The thatch layer offers protection for the pest. This is especially true when considering chemical control because thatch forms a barrier to penetration of certain pesticides used to control disease or insect problems. The pesticide is either unable to penetrate the thatch layer, or it is absorbed by the organic matter of the thatch, making control of diseases or pests futile.

It is a generally accepted assumption that as thatch increases, disease and insect problems also increase, but research documentation is sparse. Perhaps the reason for this is the difficulty of working with thatch in trying to establish a cause and effect relationship. Let's look at a few examples in the literature dealing with thatch and disease and insect problems.

Disease

It is believed that many of the facultative parasitic fungi that cause disease on turfgrass are favored by a thatch accumulation. Apparently these fungi are capable of living on dead or decaying organic matter (thatch) as well as upon live turfgrass. Therefore, thatch is an ideal growth media for the establishment of this type of pathogen. Within this group are such fungal pathogens as *Fusarium*, *Rhizoctonia*, *Helminthosporium* and *Pythium* species. An increase in the incidence of the diseases caused by these pathogens has been noted with an increase in thatch accumulation.

Pythium Blight: Many turf specialists have associated *Pythium* blight with thatch accumulation. Research by Hall, Larsen and Schmitthenner (3) indicated that populations of *Pythium* species in the thatch increased approximately ten times over that of soil, indicating that there is a potential for increased *Pythium* blight with thatch accumulation.

Helminthosporium Leaf Spot: Several researchers have shown a relationship between thatch and leaf spot. Healy (4) has shown that *Helminthosporium* species can produce large quantities of spores (inoculum) while growing on thatch. Thatch accumulation favored greater incidences of *Helminthosporium* leaf spot in studies conducted by Murray and Juska (5). Work by Colbaugh and Endo (1) indicated that thatch accumulations may favor or inhibit the incidence of *Helminthosporium* leaf spot, depending on the moisture condition of the thatch.

Fusarium Blight: *Fusarium* blight is another disease that is often associated with thatch accumulation. There seems to be some correlation, as it occurs primarily on aged turfgrass (3 or 4 years old). The causal organism is also a fungus that can live off organic matter such as thatch. This disease has been shown to be more severe on turfgrass under a drought stress (2). Therefore, a greater potential exists for Fusarium blight to occur in turfgrass with a thatch accumulation. Recent research by Smiley (8) may indicate a somewhat different correlation between this disease and thatch. In this case, the thatch decomposition itself may be more important than the amount of thatch accumulation.

Control of Diseases: Disease control would depend on the pathogen and the chemical used. Some of the chemicals are held in the thatch layer, while others may leach through the thatch. The materials bound to the thatch may give better control to those organisms in the thatch, but, if the pathogen occurs on the foliage or within the soil, then these materials would not be as effective. So there could be differing effects depending on the specific disease and the type materials used. This is a relatively uninvestigated area which may explain some of the erratic fungicide responses.

Insect Problems

As with disease causing organisms, an increase in insect problems depends on the type of insect and how thatch may influence its activity. Thatch layers seem to make little difference on population of soil inhabiting insects. However, with surface inhabiting insects, thatch may have significant influence on their activity. Again, as with diseases, the turfgrass is better able to tolerate a population of insects when in a healthy condition. Therefore, if thatch is severe and causing stress, then the turf is more prone to insect damage.

Soil Inhabiting Insects: Thatch does not seem to affect the activity of soil inhabiting insects. These insects (grubs) cause problems on thatched turfgrass as well as thatch-free turf. Since these insects live in the soil, thatch does not affect their development.

Surface Inhabiting Insects: This group of insects includes the sod webworm, chinch bugs, adult billbugs, and army worms. Thatch provides an ideal habitat for the overwintering of these insects, as it gives protection from the low temperatures, which appears to be the only direct influence that thatch may have on these insects, with the exception of the sod webworm. Sod webworms survive best in the cover of thatch and are seldom a problem on thatch-free turfgrass. Sod webworms have real difficulty in surviving in bare soil, so thatch is very important to continued populations of these insects. Thatch does not appear to be as important with the other insects within this group.

Control: Control measures are affected by the thatch, as it inhibits the penetration of insecticides, not allowing the chemical to reach the soil below. Control of the soil inhabiting insects would definitely be less effective with a thick thatch cover (6). However, thatch may improve the effectiveness of control of insects that remain on the surface or within the thatch. Many of the insecticides are absorbed by the thatch, making them more likely to come in direct contact with the surface feeding insects (7).

Continues on page 54

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Changes in Management Needed Due to Thatch Accumulation

Jack D. Butler, Department of Horticulture, Colorado State University, Ft. Collins, Colo.

The influences of thatch on turfgrass management are many. The effects of a layer of undecomposed organic matter no more than ¼ to ½ inch deep on irrigation practices and water availability can be noticeable. Also, serious disease and insect problems may be directly associated with thatch accumulation. Mowing, aerification and fertilization practices may be affected by thatch.

Thatch problems seem to become more evident when management is directed toward production of an excellent turf. In some instances thatch problems can be associated with low growing, dense, heavy organic matter producing cultivars. In other instances heavy thatch may be related closely to stoloniferous grasses or to those of a strong fiberous nature.

Heavy fertilization programs were thought to cause serious thatch problems. However, field observations do not necessarily bear this out. One fertility trial area that received up to 20 pounds of nitrogen per 1000 sq. ft. per year for several years developed no noticeable thatch. Thus, it became more and more evident that heavy thatch accumulation on many turf areas, even where management levels were high, was not "natural". Rather it resulted because of specific environmental conditions or management practices.

Turfs growing on soils that are wet and cold, very acid, sandy or heavy clay may have noticeable thatch accumulations. Whether such site conditions exist naturally or are caused by man - acid soils from use of acid-forming fertilizers, or use of "pure" sand medias for athletic fields — they may contribute to thatch build-up. It is apparent that where these factors exist to cause thatch build-up, management, topdressing, aerification, dethatching or treating with a wetting agent to counter the problem will be needed.

For many years pesticides were widely used in the turfgrass industry with almost total attention given to the control of specific pests. Ultimately, field observations began to suggest that thatch problems were sometimes severe where pesticides had been used. Such observations indicated that it was time to begin long-term field investigations of some commonly used pesticides to determine if they contributed significantly to thatch problems.

The role of microorganisms, especially bacteria and fungi, in organic matter breakdown indicate that the routine use of fungicides might greatly influence thatch build-up. This has been substantiated in a recent report (5) that indicates that long-term fungicide programs can materially influence thatch accumulation. This investigation reports that the physical depth of noncompressed thatch was significantly greater following application of certain fungicides, but not others.

Another factor, earthworms, should be considered as it influences thatch accumulation. Some early work (3) that influenced pesticide use and thinking was summarized as follows.

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Another important aspect of thatch and control relates to the various organisms that live in the thatch. The thatch layer is an ideal environment for organisms that may reduce insect populations. There are many predacious insects, mites, and other animals in the thatch that feed on insects.

Certain fungi living within the thatch may also be involved in reducing insect populations, therefore, the thatch may in some cases, be helping the turfgrass manager.

Conclusion

It is apparent that thatch and its affects on disease and insect problems is complicated. It is not simply an increase in thatch and an increase in problems relationship. There are other factors involved making this area very difficult to study. However, it can be said that there is often a relationship between disease and insect problems and thatch accumulation. It can be further stated, that if thatch is causing turfgrass stress then the turf is more prone to disease and insect problems.

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Butler *from page 54*

"Use of certain pesticides over a 3-year period caused a marked build-up of plant debris (thatch) of 'Kentucky' bluegrass (Poa pratensis L.) turf above the soil surface. Applications of the chlorinated hydrocarbon insecticides, dieldrin and chlordane, resulted in a thatch layer of 20 mm or more. The use of the carbamate insecticide, carbaryl, caused an average thatch thickness of 1.3 mm. The plots that received no insecticides or the mercuric fungicide, phenyl mercuric acetate (PMA), had no measurable thatch. The thatch depths were closely associated with plant debris weight.

In this study as the number of earthworm burrows increased, the amount of thatch decreased. Where earthworms were present to any extent, thatch was virtually non-existent. This research reitereated that earthworms are important agents in organic litter decomposition. Earthworms can influence decomposition in several ways. Among these are organic debris breakdown, giving greater surface area for increased microbal activity; they also mix organic litter with the soil.

It should be noted "that where earthworms flourish the amount of organic matter they consume is limited by the availability of supply rather than their capacity to ingest it" (4). Thus, it seems that increased organic matter production — through the use of more fertilizer and faster growing cultivars, may be offset by earthworms to the point that thatch build-up would be little, if any. Also, other benefits from earthworms such as their burrowing, which considerably improves soil aeration and drainage, should be noted.

In the early 1970's pesticide influence on earthworm populations and associated thatch problems began to be considered more often by turf professionals. Earthworm control recommendations were deleted from many published turf pesticide recommendation lists. A critical evaluation of whether or not earthworm control was necessary or desirable began to receive more attention. Earthworms on golf greens are often considered undesirable. However, many different kinds of earthworms and macrofauna occur in the soil, and many of these could be desirable, even on golf greens. Generally, a rough soil surface caused by earthworms ("night crawlers") is most common in areas of low soil fertility and shade. Proper fertilization, use of better cultivars and shade reduction are possible means of developing a better cover over the casts to reduce or elminate the rough surface problem.

Since research (3) had indicated that certain turf insecticides might induce thatch, it seemed possible that other type pesticides might also cause a thatch. A few turf pesticides, especially of the 1960's and early 1970's had dual use. For example, an insecticide might be used at a very heavy rate for crabgrass control. Also, long term pesticide use, often at high rates, might be expected to reduce earthworm populations and cause thatch accumulation. Consequently, investigations (6) were undertaken to study the influence of six preemergence herbicides (bensulide, calcium arsenate, DCPA, bandane, siduron and benefin: on thatch accumulation. This work revealed that in the fall following 2 successive spring applications, thatch had accumulated to a depth of 1.4 cm (.6 in) where calcium arsenate had been used, and to 2.1 cm (.8 in) where bandane had been used. No thatch had accumulated from the use of the other four herbicides. Also of interest in this study is the fact that "essentially no thatch accumulation was observed following the first series of herbicide treatments". This observation could help explain the lack of close association of pesticide use with thatch development.

In another report (7) it was noted that four annual applications of the six preemergence herbicides mentioned above had thatch accumulations only in bandane and calcium arsenate treated plots. Samples taken from the plots treated with bandane and calcium arsenate revealed no earthworms; whereas, there was no great difference in earthworm counts made in plots treated with the other materials or in areas not receiving treatment.

It has been reported (2) that "annual applications of insecticides to bluegrass turf over a three-year period did not create a thatch build-up. Diazinon, Gardona, trichlorfon (Dylox), fenthion (Baytex), and carbaryl (Sevin), were investigated in this study. It was also noted that when dieldrin and chlordane were applied 3 times a year over a 5 year period insecticide levels in the thatch layer were very high as compared to that in the soil.

It appears that adequate research has been done to demonstrate that certain pesticides may induce thatch. Also, thatch has been observed to accumulate rapidly where earthworms were not present. However, it has been noted (5) in a report that "thatch accumulation was not considered to be due to inhibitory effects of fungicides toward earthworms".

With these aspects in mind, it appears that thatch problems could sometimes be reduced or perhaps eliminated by using pesticides that have not demonstrated a significant influence on thatch development. More testing to determine the influence of existing and experimental turf pesticides on thatch development could provide useful management information for professional turfmen.

Some of the pesticides used in the past appear to cause long-term turf problems by influencing thatch accumulation. One area, where pesticides were applied some 20 years earlier, had distinct thatch accumulation; whereas, adjoining untreated areas had none. In this area, thatch was associated with a serious winter drought or desiccation problem.

Activated charcoal has been useful in inactivating certain pesticides, and certainly more research is needed on "turning-off" pesticides. Removal of thatch and working the soil might remove or dilute pesticides to the point where earthworms might reinfest, or be introduced into the soil. More work is needed on this possible means of thatch control. However, some work in this general area has already been done. It was reported (1) that where earthworms had been introduced the surface mat as a discrete layer disappeared.

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Integration of Control Methods Necessary to Prevent Thatch Buildup

R. N. Carrow, Assistant Professor, Horticulture Department, Kansas State University, Manhattan, Kan.

Excessive thatch accumulation results in degradation of turf and increases maintenance. Turfgrass cultural problems associated with thatch are: (a) greater susceptibility to heat, cold, and drought stress, (b) localized dry spots, (c) increased insect and disease incidence, (d) scalping, (e) reduced effectiveness and penetration of fertilizers and pesticides, (f) more wilt, (g) greater iron chlorosis, and (h) increased time, labor and money to maintain an acceptable turf.

Thatch control is not a once a year project. Instead it requires an integrated approach involving prevention, biological control, and mechanical removal. Each of these aspects requires a basic understanding of how thatch forms and how it is decomposed.

Prevention

Thatch develops in turfs because shoot growth results in organic matter accumulation at a faster rate than decomposition occurs. One approach to thatch control is to reduce accumulation by restricting excessive shoot growth. Factors which contribute to unnecessary shoot growth are discussed below.

Vigorous turfgrass cultivars: Turfgrass species and cultivars utilized for recreational turf are often vigorous. While this characteristic is important for persistence and recuperation from use, it also promotes rapid tissue production. Where feasible, the turf manager should use cultivars less prone to thatch development.

Excessive nitrogen fertilization: Thatch consists of an intertwined layer of living and dead stems, rhizomes, stolons, leaves and roots of grasses. Adequate nitrogen is required for acceptable turf quality and recuperative potential; however, excessive nitrogen increases shoot production which contributes to thatch accumulation.

Excessive irrigation: Applying excessive irrigation enhances shoot production and therefore results in thatch buildup.

Mowing and collection of clippings: Thatch accumulation can be reduced in bermuda and zoysia turfs by mowing closely. This retards total shoot production. For cool season turf, clipping removal has little influence on thatch accumulation since the leaf tissues easily degrade. Clippings contribute more to thatch buildup in bermuda and zoysia. Removal will aid in preventing thatch in these turfs; however, clippings only contribute 15-25% to the thatch.

Biological Control

The decomposition process for thatch normally involves digestion and mixing with soil by earthworm and insect activity. At the same time fungi, bacteria, actinomycetes and other microorganisms are active in decomposing various constituents within the thatch. Any factor which interfers with this natural decomposition pathway will enhance accumulation.

Promoting microorganism activity: Degradation will occur at a rapid rate if microenvironmental conditions within the thatch are suitable for a large, balanced microorganism population. The primary environmental variables influencing microorganisms are moisture, aeration, temperature, pH, organic matter, and inorganic nutrient supply. When a turf manager topdresses with a well-composted topdressing mix, he is adding microorganisms to the soil. However, more importantly he is changing the microenvironment to favor sustained microorganism activity. With topdressing soil well intermixed with thatch, moisture retention is improved. Also, due to a denser and moister environment temperature, variations are decreased. Thus, improved moisture and temperature conditions aid in maintaining an active microorganism population within the thatch.

Thatch and its decomposition products consist of a wide variety of organic compounds. To adequately degrade such a diverse assortment of compounds requires a very diverse microbial population including fungi and bacteria. Thatch tends to become acidic even if the underlying soil is alkaline. Exception to this would be if irrigation water is alkaline. When the thatch pH reaches 6.0 or less many bacteria involved in decomposing resistant components of thatch are no longer active. Thus, a light application of lime to keep the thatch

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Butler *from page 56*

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Mechanical dethatching brings thatch to the surface for removal.

Damage to turf and shrubs caused by burning thatch as a method of removal.

pH at 6.0-7.0 will aid in maximum thatch breakdown. Generally, 5-10 lbs. CaCo,/1000 sq. ft. once a year on heavily irrigated turf is sufficient. Also, maintaining a soil pH of 6.0-7.0 will help insure a good natural microorganism population.

Cultivation practices, such as coring and grooving, improve moisture and temperature relations by mixing soil into the thatch. Improved soil aeration from cultivation — coring, grooving, slicing, spiking — will aid in the maintenance of an active microorganism population. Adequate irrigation also favors microbial activity.

Promoting earthworm activity: On golf greens earthworm casts are objectionable, they do not interfere to a great extent on higher cut turf. A good earthworm population is often the cheapest and most efficient control for thatch. Earthworms digest thatch, integrate soil into the thatch, and carry some of the organic matter down into the soil. Promoting earthworm activity is best achieved by avoiding pesticides detrimental to earthworms and maintaining a favorable pH range of 6.0-7.0. Cultivation on compacted soils will aid in creating a loose, friable physical condition for earthworms.

Biological dethatching materials: Several biological dethatching agents are commercially available which consist of a dry or liquid media inoculated with specific microorganisms. These are applied to the turf and when exposed to a favorable environment the microorganisms are activated and reportedly decompose thatch. Research studies conducted at several universities (Georgia, Hawaii, California, at Riverside, Nebraska, Michigan State) have not shown any beneficial affects from these materials. Innoculation with a specific microorganism population will have little affect if the microenvironment is unfavorable for sustaining the population. Natural, as well as added, microorganisms require correct moisture, aeration, pH, etc. conditions, if they are to persist at a high enough level to influence thatch decomposition.

Mechanical Removal

Vertical mowing is the most common method used to remove thatch. On golf greens or close cut turf, vertical mower attachments are available for riding greens mowers. This allows frequent, light vertical mowing without disruption of the playing surface. However, on higher cut turf vertical mowing is normally done once or twice a year, if thatch accumulation requires it. These can be severe and result in at least some disturbance of the turf surface.

When a severe vertical mowing is necessary, at least 3-4 weeks of good growing weather should follow in order for turf to recover. For example, with a cool season grass early fall would be a good time to verticut, while mid-spring would be acceptable for a warm season turf. Care should be taken not to severely verticut just prior to annual grass germination. If it is necessary to vertical mow at that time, a good preemergence herbicide for annual grasses should be applied to prevent severe weed encroachment. Do not verticut after applying a preemergence herbicide for annual grasses or the herbicide zone will be destroyed. Maintain good nutritional, moisture, and other growing condition after vertical mowing to insure rapid turf recovery.

Sometimes when a turf with rhizomes or stolons has developed a thick thatch, the turf can be stripped and allowed to recover from rhizomes or stolons that remain. Turning the sod under is generally not desirable since mixing it into the soil is difficult. This method is unsightly and requires several weeks for recovery.

Burning is sometimes used to remove thatch, particularly on bermuda. This method can reduce thatch but it is not without problems. If a thick thatch exists, the plant crowns may be elevated into the thatch. Burning can then result in high temperature kill of the crown, even on dormant turf. If burning is used it must be rapid and preferable with a moist soil. Burning should not be attempted around houses or where evergreen trees and shrubs are present.

Thatch is not a desirable turfgrass growing media. The turf manager should not consider mechanical removal as a routine maintenance practice. Instead he should give careful attention to preventing excessive shoot growth and promoting maximum decomposition. Mechanical removal is expensive and time consuming and should be used only as a last resort.

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CIL Sulphur Coated Urea is being tested against other controlled release nitrogen fertilizers at 14 different universities in the U.S. and Canada. Photo above shows one of the test sites with CIL Sulphur Coated Urea treated grass in foreground.

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Efficient

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- Soil ph does not alter pattern of release.

Background photo:
CIL Sulphur Coated Urea prills actual size.

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Reclamation *from page 43*

Although some of the soluble sulfate may then precipitate out as gypsum ($CaSO_4 \cdot 2H_2O$), high levels of calcium and sulfate remain in solution. Much of the iron may precipitate out as iron hydroxide.

Soils workers commonly measure salt levels, which can be equated to TDS, as electrical conductivity (EC) and plant physiologists interpret salt effects in terms of osmotic pressure (Salinity Handbook 1954). A large osmotic disparity between the soil solution and plant cells can lead to unfavorable water relations and consequent impaired growth and photosynthesis, and even plant death.

Drought markedly increases the effects of dissolved ions.

Plants differ markedly in their tolerance to salt levels. As reported by Jackson (1958) EC may affect germination at 1 mho/cm, reduce growth of some "salt"-sensitive plants at 2, and result in severe injury to many species at 3 mho/cm. Some plants can grow at much higher salt levels. Plants adapted to high-salt soils have been found to increase their cell-sap concentration and maintain a favorable osmotic gradient and water supply (Ashby and Beadle 1957).

Salinity problems have been reported chiefly in relatively arid climates where pH, EC, and soluble sodium content are associated. Most natural soils of the humid, midwestern United States have low EC values irrespective of pH, and low sodium content. In contrast, midwestern mine spoils often have high TDS/EC values from sulfate, calcium, and iron.

Drought markedly increases the effects of dissolved ions. As soil moisture is depleted by evaporation and transpiration, the concentration of dissolved ions becomes progressively greater and some may even reach saturation. Roots thus may actually encounter concentrations of dissolved ions much more limiting than those measured using laboratory procedures.

Use of high-salt plants may be the most successful means of coping with TDS/EC levels. An established cover of adapted plant species will mitigate salt problems by reducing salt levels through ion uptake, and by furnishing a mulch on the soil surface and developing root channels which improve water movement down through a soil to hasten leaching losses of excess salts. Subsequent effects on stream quality must be considered.

Halophytes, or plants adapted to salts in soils, are characteristic of western areas with low precipitation. Some western species such as kochia which have flourished as weeds on midwestern stripmines may scarcely be present on adjacent farmlands. Their vigor may be related to an ability to compete favorably with typical midwestern species on mined soils with high TDS. The value of hardy pioneer plants in re-establishing vegetation should be recognized. Use of suitably adapted plants, within the constraints of management, is a key to successful reclamation.

Conclusions — Many stripmines differ from surrounding agricultural lands. The degree of difference is a variable related to type of overburden, climate, and other factors. Agricultural lands are typically ion-poor, and stripmines ion-rich. These ions are released from sedimentary rocks and minerals brought to or near the surface where oxidation and other weathering processes can take place. Iron sulfide (pyrite) is the dominant geochemically active mineral in overburden materials. It may be present in small but important amounts.

Pyrite oxidation liberates hydronium, ferrous, sulfate and other ions directly and calcium, magnesium, manganese, iron, aluminum, and other ions indirectly. Under present regulations acidity from pyrite oxidation which is not neutralized by basic materials in the overburden is controlled by applications of lime and other soil amendments. Some ions such as iron precipitate out at higher pH. Many ions such as sulfate or calcium remain in solution and are measured as high levels of total dissolved solids typical of mined areas. As soils are leached these ions move from sites of production to drainage waters. The loss of ions may be slow compared to the production.

Plant growth depends on a supply of ions from the soil and may be enhanced by the increased availability of minerals on mined lands. Acidity is not necessarily harmful to plant growth. An imbalance of ions, an excess of one ion, or a very high level of total dissolved solids can be deleterious to growth of some species. The plants to be used in reclamation should be carefully chosen for the site, particularly if the site cannot readily be changed to suit a certain species. Both native and introduced species or varieties may have suitable ranges of ecological tolerance for use in revegetation.

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JAPANESE BEETLE CONTROL: BIOLOGICAL AND CHEMICAL

While control of Japanese beetle larvae is a significant aspect of turf management in many areas, the larvae are only one type of several "white grubs" that may be inhabiting the soil. When applying a specific control for Japanese beetle larvae, specific identification is necessary.

The presence of grubs in general may be indicated by feeding activity of such animals as moles, armadillos, skunks, or large flocks of birds. The only way to specifically identify a grub problem, however, is to expose a portion of the turf rootzone and visually inspect it. The recommended manner is to expose a square foot of turf, two to four inches deep, and examine it for larvae. Several samples should be taken in any one area.

Japanese beetle larvae are white with a brown head. They are found, curled in the typical "C" position, in the soil around grass roots. They are distinguished from other grubs by the rastrel pattern.

The life cycle of the Japanese beetle is completed in one year. Adults lay eggs in mid-summer. By August, the larvae have hatched and are actively feeding on turf roots. The larvae then overwinter in the soil, and in the spring they rise to the surface again and feed. Adults emerge in June or July.

Milky Spore Disease

In 1933, scientists with the United States Department of Agriculture in New Jersey discovered a number of Japanese beetle larvae to be filled with a milky white fluid teeming with bacterial spores. The spores were identified as *Bacillus popilliae*. It was found that grubs infected with this disease died and left disease spores in the soil that would infect other grubs feeding on grass roots in that vicinity. The spores were found to be very resistant to dryness, cold, heat, and moisture, and remained viable in the soil medium for years.

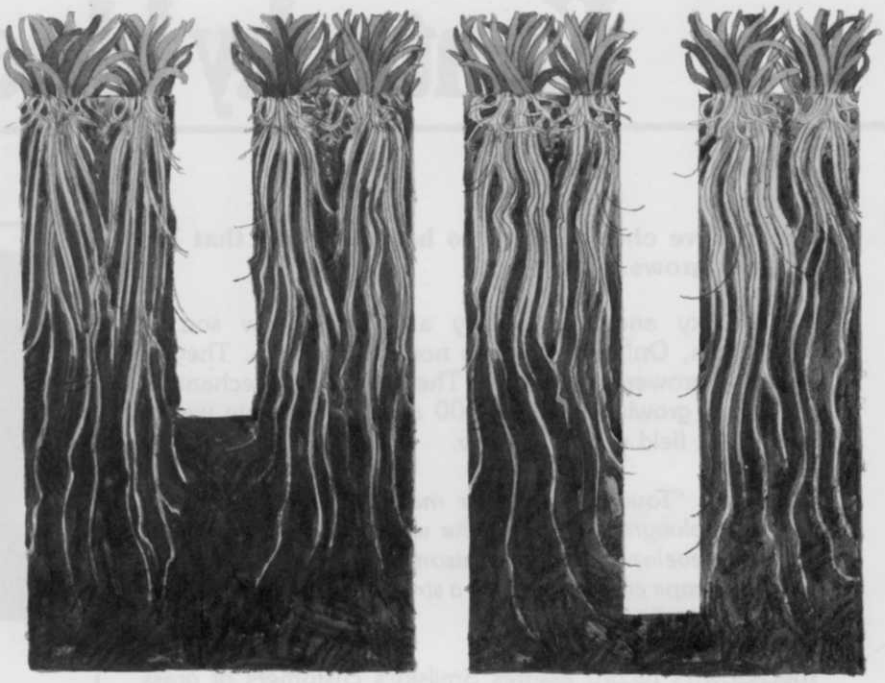
Milky spore disease powder is prepared in the laboratory by growing numbers of infected grubs. The spores are mixed with a dust-type base and packaged. The powder is then spread over a grub infested area and washed in.

Recommended rates of application vary according to source, but it is generally agreed that the powder is placed in teaspoon heaps at distances of three to ten feet apart. Applied at the rate of one teaspoon per four feet, treatment equals ten pounds per acre. That rate is recommended by Reuter Laboratories, one producer of the disease powder.

Although the disease spores begin working immediately upon contact with feeding grubs, it

Grubs (larvae) feed on turf roots from August to winter and again in the spring.

Which aeration hole is better for your greens?



The answer, if you haven't already guessed, is the Greensaire II hole. And for good reasons.

One, it's deeper. The primary objective of aeration is to help air, water and fertilizer penetrate the soil. The Greensaire II removes cores up to 3″ deep, allowing these vital nutrients to reach the root zone where they're needed.

The fact that there are 36 of these deep holes per square foot means that you also remove more soil. This not only relieves the toughest compaction problems, but it also allows you to replace more of the old, depleted soil.

The Greensaire II hole is precise. It won't affect the roll of a golf ball, so your green is back in play sooner. You can aerate most greens in 45 minutes or less.

And when you use the Greensaire II, you can also use the unique Ryan Core Processor attachment. It catches the cores, separates good soil from debris, puts the good soil back on top, and bags the debris. You aerate, top dress and collect thatch in one operation.

If you want these same fine aerating qualities, but on a smaller scale, choose the Greensaire 16. It aerates a 16″ swath instead of a 24″, uses the same selection of tines and has a convenient windrow attachment that makes core removal easy.

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can take up to three years for full distribution within a turf area. The first symptoms of the disease should appear in grubs during the first one to two weeks, depending upon temperature. The disease will not develop at temperatures above 97 degrees F, and therefore cannot infect warm-blooded animals with higher body temperatures. It should be emphasized that milky-spore disease is not an insecticide, but a biological control agent.

The bacteria have two stages in their life cycle. During the spore stage, the bacteria are inactive and in a resistant condition. Once the bacteria are ingested by a feeding grub, they become active and multiply rapidly. Upon death of the grub, five billion or more spores may be released in the soil to infect other grubs. The length of time for disease spores to be distributed throughout an area depends upon natural movements of the grubs. The more larvae in the soil, the faster the disease spreads.

Some judgment is needed to decide whether to apply a chemical insecticide along with the milky-spore powder. Obviously, a high grub population will rapidly decimate a turf area. Some grub activity is necessary, though, to spread the disease spores. Milky-spore disease will remain, however, to prevent future crippling attacks by Japanese beetle larvae.

Grub

Adult

Chemical Control

Chemicals for control of Japanese beetle larvae include: chlorpyrifos (Dursban), diazinon (Dizazinon, Spectracide), fensulfothion (Dasanit), and trichlorfon (Dylox, Proxol). Refer to labels for specific labeling use directions.

Adult beetles can cause problems by skeletonizing foliage. Their control is more difficult, as new beetles are constantly flying from plant to plant. Most controls last only three to four days and must be repeated as necessary. Chemicals include: carbaryl (Sevin), methoxychlor (Marlate) and Sevimol. Again, refer to labels for specific directions. **WTT**

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With Exhalt® 800 78% of your fungicide is still working even after a 2-inch rain...

Unique encapsulating action makes it possible.

Percentage of fungicide retained after rains, Exhalt 800 versus Brand X:

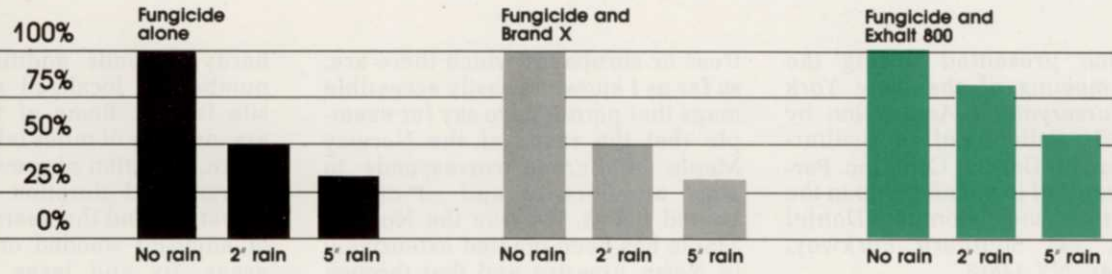


Chart shows how Exhalt 800 resisted wash-off in a laboratory test. Spray coatings were applied to glass panels and dried 10 minutes at approximately 70° F. Retention after erosion by rain was measured by solvent stripping the panels and determining the residual fungicide by quantitative ultraviolet spectroscopy.

See how Exhalt 800's encapsulating action guards against costly fungicide wash-off:

This test with Exhalt 800 shows 78% of fungicide was still intact after a 2-inch rain. Even after 5 inches of moisture, 60% was still in place.

We're painfully aware that you may be disenchanted with spreader-stickers, so we want to emphasize that Exhalt 800 is *not* a spreader-sticker. Rather it is a *Sticker-Extender*, and there's a world of difference!

The *spreader* part of a spreader-sticker is a detergent that actually assists in wash-off. Exhalt 800, on the other hand, has a unique encapsulating action that causes fungicide to *resist* wash-off.

Simply stated: Spreader-Stickers *assist* wash-off; Exhalt 800, a unique Sticker-Extender, *resists* wash-off.

Defies Rain

To illustrate its clinging power, let's suppose you have added Exhalt 800 to your fungicide and treated 18 greens. An hour later a dark, menacing cloud rolls in; in the next 45 minutes it dumps two inches of rain on your treated greens. What now?

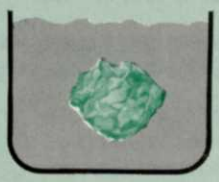
Obviously, some of your treatment is washed away. But the silver lining is . . . *some 78% of it is still in place and working.* Thanks to Exhalt 800's unique encapsulating power, you won't have to repeat the whole costly process again tomorrow.

Even in arid regions plagued with occasional fungus flare-up, Exhalt 800 pays. It lets you spray and, after an hour, irrigate. With no more worry about losing your greens to either fungus or drought.

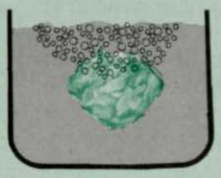
The Exhalt 800 difference

Unlike spreader-stickers that wash off with the first rain, Exhalt 800 (a sticker-extender) clings with encapsulating power. It's an extremely sticky, flexible, fabric-like protector that encases every fungicide particle, keeping it in place and working despite rainfall.

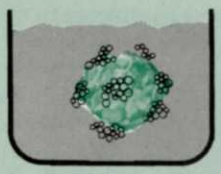
A closer look at Exhalt 800's unique encapsulating action:



One miniscule fungicide particle, greatly magnified. Countless millions of such particles in water become the spray solution.



Exhalt 800 enters spray tank. Hydrophobic (repelled by water), it breaks into myriad of tiny droplets and attaches to fungicide.



Tiny Exhalt 800 droplets form a porous "fabric" that encapsulates every fungicide particle, causing it to cling to turf or foliage.

To get a clear picture of Exhalt 800's superiority, study the chart above. This test, important though it is, is just one of many. Our files hold much other massive evidence of Exhalt 800's unique encapsulating power: the field-test data from many leading universities (test results available on request).

While Exhalt 800 is used extensively on turf, it also is registered for use with insecticides for trees and ornamental shrubs. In every use, it lets plants "breathe," grow and develop normally. It's economical and easy to use.

Exhalt 800 is effective with most brands of wettable-powder and flowable fungicides, including Gordon's Dymec 50™, Formec 80™, and Topmec 70W™.

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TREES AND SHRUBS RECOMMENDED FOR HARDINESS IN THE NORTHEAST

A speech presented during the March meeting of the New York State Nurserymen's Association by William H. Collins, staff horticulturist, American Garden Cole, Inc. Persons interested in membership in the Association may contact Daniel Perkins, 144 Southern Parkway, Rochester, NY 14618.

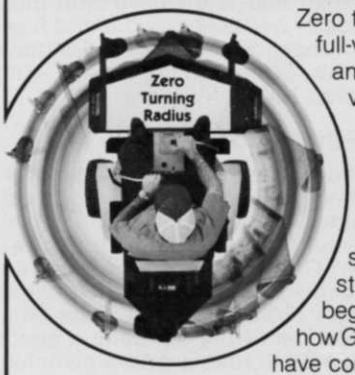
Hardiness zones are probably the best single indicator for judging the general adaptability of trees and shrubs to a specific area. We would all feel more confident if there were similar but additional data that individually covered other weather factors such as the seasonal changes in rainfall, humidity, wind, elevation, days of sunlight and the like.

Most of us are further stymied by trying to fit into our U.S. hardiness zones, the many exotic (introduced) trees or shrubs for which there are, so far as I know, no easily accessible maps that permit us to say for example that the range of the Norway Maple of Europe corresponds to zone numbers so and so of the United States. It's true the Norway Maple has been planted extensively in North America and that through trial and error we can set up a pretty valid comparison. But what of the many Asian introductions whose origins and climatic conditions we know even less about. Where they were first collected may not be a total indication of their full range of adaptability in this country. Some of the Asiatic maples and birches are in this category and perhaps some of the elms and lindens.

Having lived along the south shore of Lake Erie and Lake Michigan and the north shore of Lake Ontario, I can understand that the evidence of what is, and what is not hardy depends additionally on a number of localized weather and site factors. Some of these factors are, number of miles inland from the shore, direction of prevailing winds, amount and duration of snowfall, elevation, and the nearness and size of adjacent wooded or open space areas. By and large these areas bordering large bodies of water are favored areas plant-wise. The extensive variety of plant material in the Morton Arboretum near Chicago, the Holden Arboretum near Cleveland, the Hamilton, Ontario Botanic Gardens and the notable woody plant collections in the Rochester area, both bordering Lake Ontario, indicate their more stable climates.

Region 5 of the New York State Nurserymen's Association (Genesee Finger Lakes Nursery Association) corresponds to a similar sized area in Ohio extending about halfway down the state from Cleveland.

Mowing Faster with a Grasshopper Cuts Lawn Maintenance Costs



Zero turning radius maneuverability of an out-front, full-view mowing deck moves mower operators on and off lawns in up to half the time spent with conventional equipment . . . a big labor savings at every mowing.

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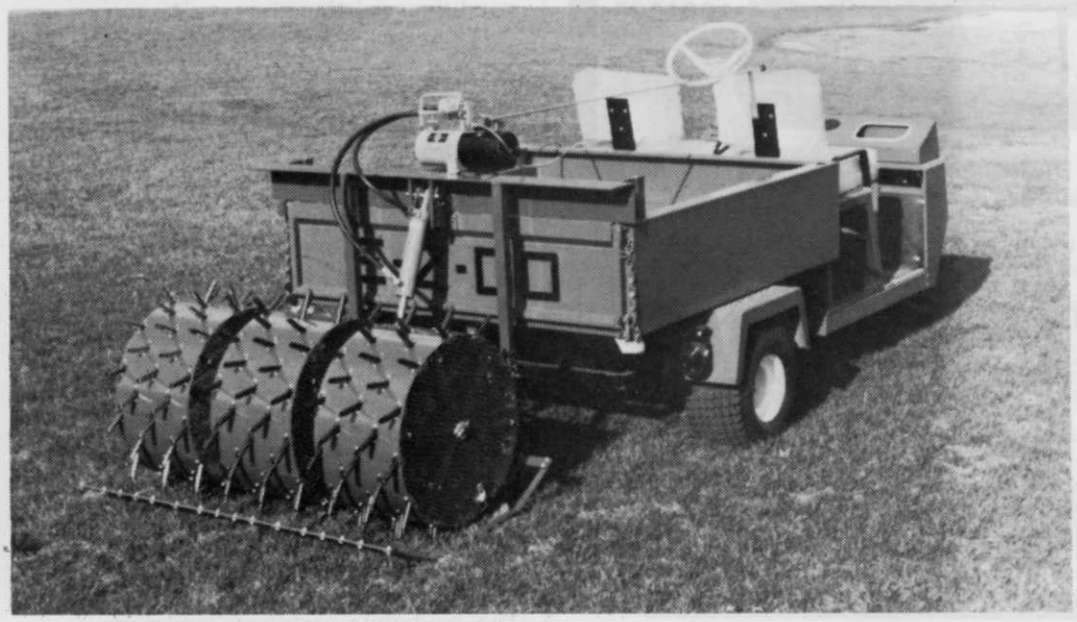

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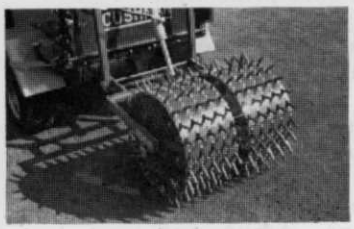

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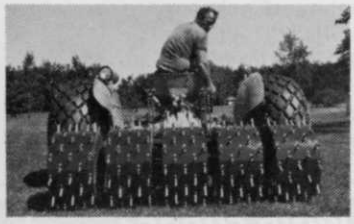

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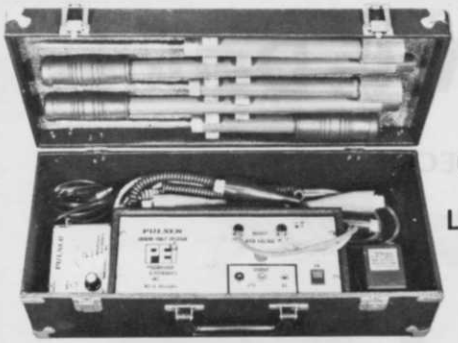

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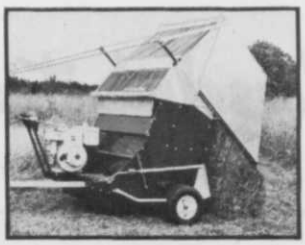
36", 60", 72" cutting widths - with or without loading hopper.



Mathews Company
BOX 70, CRYSTAL LAKE, IL 60014, PHONE: 815-459-2210

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Hardiness

There is one major difference. The New York area is one hardiness zone colder. Fortunately they're still able to plant most of the species we consider choice ornamentals.

We recognize that the growing conditions existing at some sites may contain specific physical or stress restrictions that limit the successful use of an otherwise adaptable variety. Conversely we have the opportunity to extend the landscaping palette by using some plant material tagged one or two zones less hardy if we provide the conditions needed for acceptable growth. A few examples of site modification are the use of protection afforded by northern and eastern exposures; improving drainage by tiling, mounding or amending the surface soil layer; planting or building windbreaks; establishment of overhead plantings to create filtered or high shade; and the use of ground covers. We frequently place Magnolias, Azaleas and Rhododendrons, Oriental maples, and great many of the broad-leaved evergreens in this category. The landscape architect, landscape contractor, retail nurseryman and garden center manager cooperatively share tremendous pride with the client when "ify" plant material is successfully established. Prestige in the plant business results from continuously doing most things a little better than your competitors.

With the exceptions noted, the following in small to medium sized trees are considered dependable in Region 5: Maples, Amur and Japanese; Hawthorns, many but especially Washington, Cockspur, Dotted, Toba and English. The thornless form of the Dotted Hawthorn, 'Ohio Pioneer' and the Cockspur Hawthorn 'inermis' are especially suitable where the situation calls for

Put a WHIRLWIND FORCE to work to SWEEP UP LEAVES, LITTER, etc!

TAKE-ALONG 'BIG JOB' LOADER
HAUL THIS 16 horsepower Mi-T-VAC on any truck (or trailer we make) and clean up wet or dry problems. Fills dump truck with leaves in 25 minutes!

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HEAVY DUTY BLOWER-SWEEPER helps a small crew gather more leaves, trash, clippings in less time. For details on today's 5 to 45 horsepower models, call Area 216 **947-2344**.

ATWATER STRONG DIVISION OF ATWATER INDUSTRIES, INC. MODEL 8K
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LAWN EQUIPMENT SINCE 1949

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Turf-Type Perennial Ryegrass

Setting a New Standard of Excellence

Derby is the dark green beauty which joined Manhattan and Pennfine on the "highly preferred list of ryegrasses." That was last year. Now Derby is setting a new standard of excellence.

In the eyes of many Golf Superintendents it reigns supreme among the turf-type ryegrasses today. Why? Because it performs! And a Superintendent knows that claims are great, but performance counts.

- Consistently performs better than other leading varieties from California to Florida
- Durable, dark green and has excellent mowing qualities
- Tolerates a variety of soils & responds rapidly to fertilization
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- Better-than-average heat and drought tolerance
- An adaptable and disease resistant cool-season turf grass
- An excellent record as a Southern winter grass
- Thrives when close-cut

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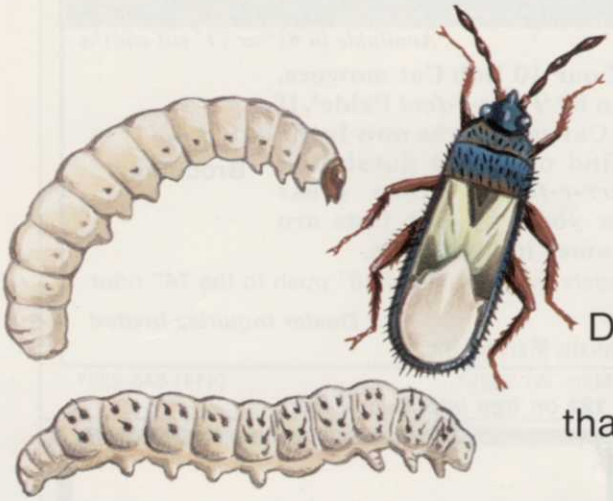
HIRE THE INSECTICIDE THAT LIKES TO WORK OVERTIME.



DURSBAN* brand insecticides provide unsurpassed residual control of cutworms, chinch bugs, sod webworms, and a dozen other turf pests. Both DURSBAN 2E Insecticide and double-strength DURSBAN 4E Insecticide keep working a lot longer than other turf insecticides. This residual action saves you time, trips, and labor. It also saves you money. In fact,

DURSBAN insecticides cost less than most other turf insecticides. Ask your supplier for the turf insecticide that works overtime for you. Get DURSBAN 2E Insecticide or double-strength DURSBAN 4E Insecticide. Just be sure to read and follow all label directions and precautions. Agricultural Products Department, Midland, Michigan 48640.

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Professionals Use Bob Cats with Purr-r-fect Pride!

Available in 61" or 74" cut widths

If you are using one of our 10 Bob Cat mowers, you know what we mean by *'Purr-r-fect* Pride'. If you haven't tried a Bob Cat yet, maybe now is the time to do it. You'll find out what durability, dependability and *purr-r-fectly* mown grass really are. Let us show you why Bob Cats are becoming the biggest names in lawn care.

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Ask for the true "cutting-grown" TALLHEDGE™. Excellent for all types of landscape screening, property line separations and backgrounds. There is only one TALLHEDGE™ . . . from the Originators, American Garden Cole.

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Where great new plant ideas take root.

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a thornfree form. Neither are yet used to the extent we believe they will when better known.

Flowering crabapples are a top-ranking group all across northern areas. To our benefit most of the newer flowering crabapple varieties are improvements over previously introduced selections. These better varieties have greater resistance to disease and most bear smaller sized fruit, two of the very best reasons to consider switching to some of them. Nurserymen in Region 5 are uniquely well situated to use the flowering crabapple performance data published annually by Professors Nichols (Plant Pathology) and Brewer (Horticulture) of The Pennsylvania State University. Their 1978 report "Flowering Crabapples in Central Pennsylvania" was released earlier this year. It's easy to see the landscaping advantages of small fruit, so why not select the best from among them, those that give you greater mileage in beauty because the fruit persists attractively on the trees for months longer. Malus 'Red Jewel' was rated in this report — "Excellent, showy red fruit by 11/21". Fruit size was as small or smaller (¼-⅜ inch) than any of the 10 kinds whose fruit did persist as late as November 21, 1978. No apple scab reported on Red Jewel for 1978 at the Rock Springs Research Center.

European Mountain Ash is especially colorful in northern areas, including all the Great Lakes region. Fruit appears to color brighter and the foliage is freer of the shabby look the leaves take on in areas having warmer and drier growing seasons.

Japanese Tree Lilac with cherry-like bark on older trunks is at least a three season beauty — creamy-white, cone-shaped flower clusters, heavy textured leaves all season and the cherry bark winter color. Where grown and planted on sites requiring 5 feet or more of clearance, they are customarily "spec.-ed" single-stem, tree form, but specimens with 2 to 5 trunks limbed up to a corresponding height are just as useful and much more attractive. One other advantage. If one trunk is lost by injury, the top in several years will still "round-out".

The Sheridan selection 'Ivory Silk' introduced through the Canadian Ornamental Plant Foundation is described as a sturdy, compact tree-form selection flowering at an early age. This is exactly the type needed.

In larger trees, we can never seemingly over plant the sugar and red maple. Both mature into large specimen trees. When we crowd either the roots or tops, but especially the root area, the trees may show stress symptoms — leaf scorching at first, then slowed annual growth, then twig die-back starting on the extremities of the top and outer branches. When either of these trees are to be planted in some kind of man-made root area, pit or above ground, argue persuasively for the largest soil volume possible with square footage of surface area predominately important. The upright, columnar to narrow pyramidal forms are best where space between trees or other features is minimal.

Among exotic (introduced) trees that we feel quite comfortable with are European Beech, Norway Maple and Little Leaf Linden. Natives we continue to plant are Pin and Red Oak, White and Green Ash, Honeylocust, and the several birches. A number of nurseries and governmental institutions are working to determine which of the so-called white barked, borer-resistant birch species from Asia are best. Seedling populations of several kinds are just now becoming available in the trade and more will be soon.

Back to the smaller trees, Japanese maple properly sited gets more beautiful and more valuable each year it ages. The species and its selections in large sizes seem to be continually in short supply. Redbud is a perennial favorite. It is unfortunate more growers are not propagating the white and pink forms, but especially the pink. An eight to ten foot specimen of Wither's Pink Charm is breath taking.

With promising new Magnolias coming from the efforts of The National Arboretum and dedicated Magnolia breeders both here and abroad, it could easily be worth your while to try some of them even if available only in small sizes. Do what many nurserymen do. They plant them in their own landscape plantings until large enough to move B&B to a permanent site where they can be further observed and photographed.

We presume that Golden Raintree, Yellow-wood and Japanese Pagoda still head the list of summer flowering trees if there is evidence in your area that flowering age trees are doing just that. **WTT**

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MANUFACTURERS OF AGRICULTURAL, TURF & INDUSTRIAL EQUIPMENT
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1950 Turf Sprayer

Broyhill's outstanding value in an all-purpose sprayer. The 1950 Turf Sprayer is available as a skid or trailer unit with 100, 150 or 200 gallon polyethylene and stainless steel tanks. Choose the pressure and gallonage performance you need from three pumping systems. With mechanical or jet agitation.

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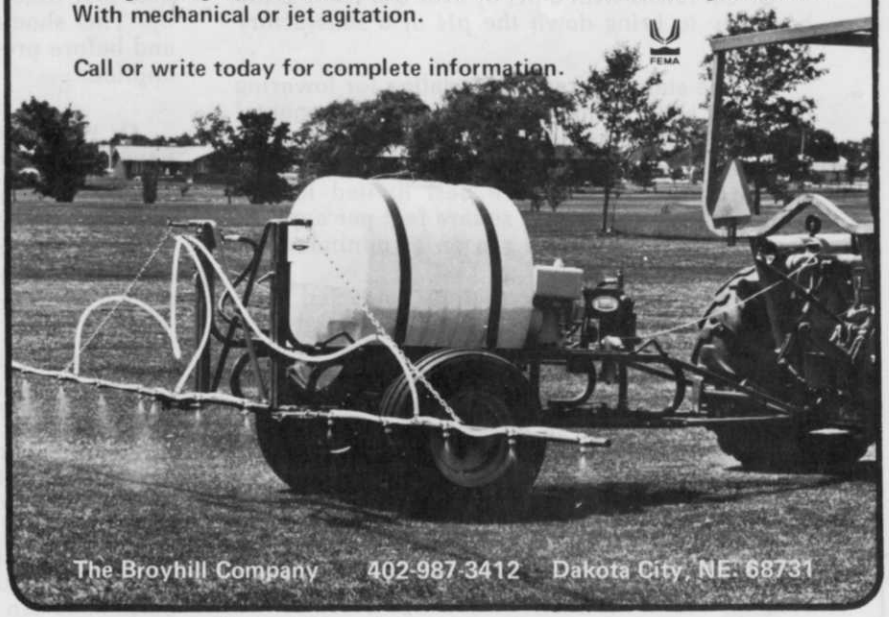

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Model 426 self-propelled Mist Blower; 32-gal. formula tank; 12.5-hp high-performance engine; standard cleat or ATV tires.

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VEGETATION MANAGEMENT

By **Roger Funk,** Ph.D., Davey Tree Expert Co., Kent, Ohio

Q. *On lawns with a pH of over 8.0, what is the best way to bring down the pH of a satisfactory level?*

A. The standard recommendation for lowering the pH of soil solution is applications of elemental sulfur or sulfur-containing compounds such as iron sulfate and aluminum sulfate. Applications of sulfur to established turf are best limited to five pounds of sulfur per 1000 square feet per application during the dormant season to minimize the potential for "burn."

Although we have successfully corrected alkaline conditions in sandy soils, fine textured soils that are inherently calcareous may resist acidifying treatments because of their tremendous buffering capacity. It is often more feasible to modify the fertilizer treatments to compensate for alkaline-induced deficiencies rather than to attempt to correct the pH.

Q. *I have been told that I can scalp turf in the spring to help eliminate thatch, but I thought that scalping injures the grass.*

A. Turfgrasses can be scalped in early spring before greenup since most of the existing leaf tissue will be replaced with new spring growth. However, after growth has occurred, scalping will upset the equilibrium between the root and shoot systems and cause a stress condition. Also, as the temperature gets warmer, scalping can expose the turfgrass crown to excess heat and drying, which could seriously injure or kill the turfgrass plants.

Q. *Is it true that liquid fertilizers are absorbed by turfgrass leaves and do not promote root growth?*

A. Some of the liquid fertilizers will be absorbed by turfgrass leaves, but it is not true that liquid fertilizers promote foliage growth without a supporting root system. In fact, granular fertilizers must dissolve in soil solution to form the same nutrient ions that are in liquid fertilizers before the plant root can absorb them. The major difference between a liquid and a granular fertilizer is the rate at which these nutrient ions are released and, therefore, available for root absorption.

Q. *Last year many of the lawns we serviced had snow mold and it left bare spots. If the same thing happens this year, should I put down a fungicide?*

A. Applications of fungicide for the control of snow molds must be made in late fall before snow cover. Chemical treatments in the spring — after the damage has been done — are not effective.

Since snow molds usually kill only the turfgrass leaves, the crown area of the plants will produce new leaf tissue if the dead, matted grass is raked up. This should be done before spring green-up and before pre-emergent crabgrass herbicides are applied.

Q. *What should be done for ornamentals that have been injured by the cold, winter weather.*

A. Prune out the dead wood, lightly fertilize and keep the plants well watered (don't overdo it) during the summer months. Mulch applied over the root system in the fall will help keep freezing temperatures from penetrating into the root zone.

Q. *I need current information on options for control of poison oak, also remedies for skin contamination from poison oak.*

A. Compounds such as Amitrol-T and Weedazol, which contain aminotriazole, are labeled for the control of poison oak. Be sure to read the label to determine if these products can be applied under your conditions.

The potential for skin contamination with poison oak can be minimized if protective clothing is worn and laundered immediately after application. A number of non-prescription creams and lotions which contain drying agents and relieve itching are available at drug stores. Among the most common products are Ziradryl, IVarest, and calamine and caladryl lotions. Severe allergenic reactions should be referred to a physician.

A. *What type of agitation — mechanical or Venturi — is more effective for wettable powders, and why?*

A. Mechanical agitation is usually more effective in suspending wettable powders. Hydraulic agitation will provide adequate suspension if the pump has sufficient capacity. Placing jets on the end of a separate pressure line for recirculation of 10% of the tank capacity per minute is usually recommended.

Q. *What green dye product can be mixed with Trimec weedkiller to give the lawn a better appearance?*

A. There are at least a dozen dyes or pigments on the market that will safely color turfgrasses. The dye formulations have a shorter residual than the plastic or latex pigments because they fade in the sun and wash off with water.

Among the products we have tested are Greenzit (W. A. Cleary Corporation), Winterlawn (Virginia Chemicals), and Ever-Bright (Davis Paint Company). All of these materials will stain pavement, etc., unless precautions are taken; and if applied during the growing season, they will be mowed off as the turfgrass grows.

ARBOTECT® 20-S
The strongest Dutch elm disease protection you can give a tree.

ARBOTECT 20-S fungicide helps make it possible to save many elm trees that otherwise would be lost.

Injected into the trunk of the tree, ARBOTECT builds a barrier against Dutch elm disease inside the tree itself. It helps prevent the disease in healthy elms, and can often save infected trees if they are treated early enough.

Used along with sanitation, insect control, and root graft elimination, ARBOTECT can significantly improve the effectiveness of a Dutch elm disease control program.

ARBOTECT differs from other elm fungicides in several important ways:

- It is registered at rates high enough to be effective.
- It is concentrated, requiring much less water for injection, so trees can be treated much faster.
- Thiabendazole, the unique active ingredient in ARBOTECT, is highly effective against *Ceratocystis ulmi,* the fungus that causes Dutch elm disease.
- Even though it is more effective and convenient, ARBOTECT costs about the same to use as other elm fungicides.

This year, put ARBOTECT to work in your disease control program. It's the strongest protection you can give an elm against Dutch elm disease.

Arbotect

Strong protection for elms.

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Rahway, New Jersey 07065
ARBOTECT (thiabendazole) is a registered trademark of Merck & Co., Inc.

Circle **163** on free information card

PRODUCTS

Kawasaki Motors Corp. is now marketing their small air-cooled engines in North America. The small two-cycle engines are from .8 through 4.3 horsepower; four-cycle engines range from 2.3 through 20 horsepower, and larger two-cycle engines are available through 70 horsepower.

All Kawasaki four-cycle engine models are suitable for industrial and commercial use. They include such standard features as: ball bearings on both ends of the crankshaft and camshaft, mechanical governor, stellite-faced exhaust valve, cast-iron cylinder or cylinder liner, and high quality air and fuel filtration systems. All help to increase engine life. The 8 through 20 horsepower models also include counter balance shafts and the 14 and 20 h.p. models have an internal trochoid oil pump.

All two-cycle engines are equipped with ball or needle bearings on each end of the crankshaft, chrome-plated or cast-iron cylinder liner and forged steel connecting rod with bushing or needle bearings on each end. All engines are quiet and smooth running.

Circle 701 on free information card

A new model, featuring a liquid-cooled industrial engine has been added to Excel Hustler line of commercial mowers built by Excel Industries, Inc.

The significant difference between the new model 295 and the acre-proven 285 is its engine. Unlike automotive type engines commonly installed on mowers, this 2-cylinder, long stroke Continental engine develops high torque at lower RPM, which adds to engine life and delivers superior performance. Its manufacturer claims easier servicing, lower upkeep, and less downtime; Excel engineers are enthusiastic, viewing it as the ideal choice to meet market demands by groundskeepers whose specs require a liquid-cooled engine.

Dual hydrostats move each drive wheel independently, with twin hand levers that control both the speed and direction of movement, including the start and stop as well as reverse. The big 72" mower can perform intricate turns without time-consuming antics that mark ordinary mower operation; this also relieves operator fatigue, a claim based on input from present Excel Hustler owners.

The line is built with a full safety package, and attachments that permit year-round use of the tractor are available. Excel Hustler mowers qualify for GSA and HUD purchases.

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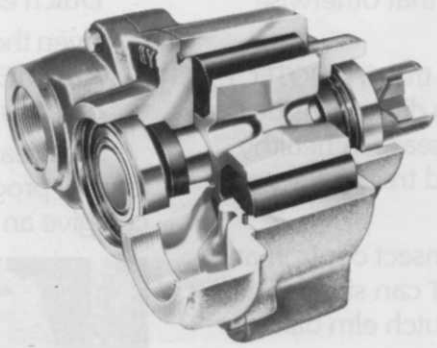

A large capacity roller pump capable of delivering up to 80 gpm at speeds to 600 rpm and pressures to 150 psi is being manufactured by Hypro Division of Lear Siegler, Inc.

The Series 1100 pump is designed for operation at 540 rpm tractor power take-off speeds and combines the performance range of multi-stage centrifugals with pressure advantages of positive displacement pumps. It is available with 6-spline

Embark® Plant Growth Regulator
is available at these locations:

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696 Naplus Street
P.O. Box 935
Chula Vista, CA 92012
Attn: Ralph Cramer

Wilbur-Ellis Co.
P.O. Box 1286
Fresno, CA 93715
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VanWaters & Rogers
1363 South Bonnie Beach Place
Los Angeles, CA 90023
Attn: Paul Sanders

Moyer Chemical Co.
1310 Bayshore Highway
P.O. Box 945
San Jose, CA 95112
Attn: Donald Meyer

VanWaters & Rogers
2256 Junction Avenue
San Jose, CA 95131
Attn: Bevan Cates

Moyer Chemical
230 East Dyer Road Unit
Santa Ana, CA 92707
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Wilbur-Ellis Co.
14111 Freeway Drive
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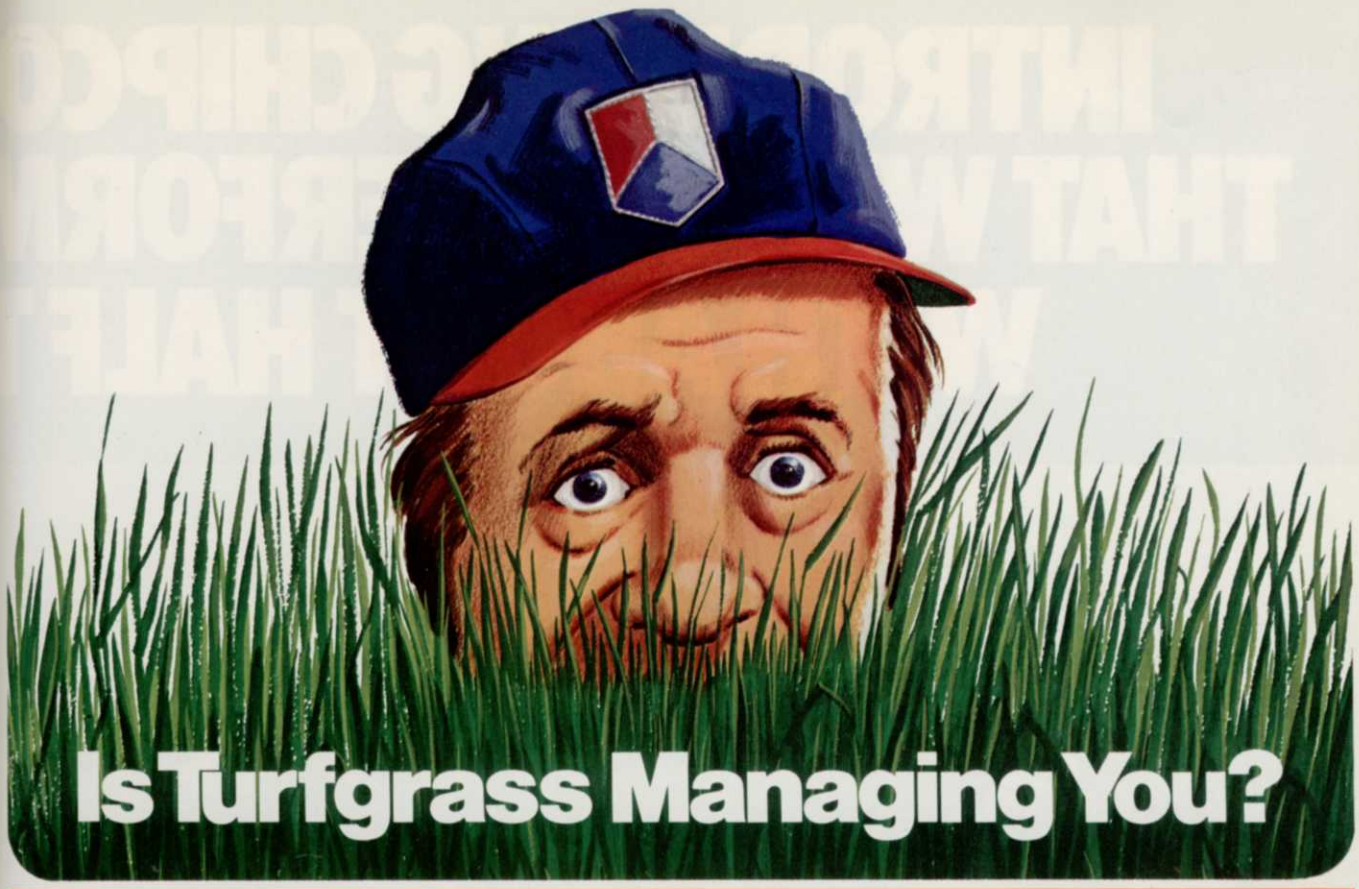

Embark® Plant Growth Regulator Puts You In Command–

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Slows Turf Growth When and Where You Need It.

This spring and summer, you decide when to send your mowers into action!

"Embark" Plant Growth Regulator reduces turf growth without injuring grass or inhibiting root development. That means less mowing and more time for other jobs.

A spray application of "Embark" Plant Growth Regulator on actively growing turf lasts up to eight weeks.

For hard-to-mow areas—roughs, along fences, highway embankments—"Embark" Plant Growth Regulator keeps most commonly-grown species* of grass on hold. Saves equipment and labor. Plus takes the pressure off a busy season.

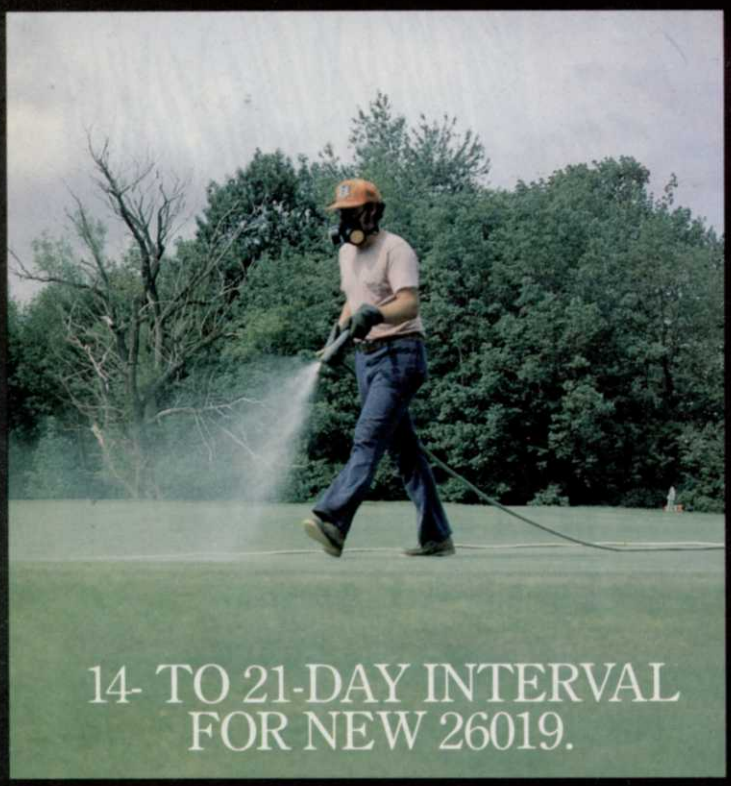
This year make "Embark" Plant Growth Regulator part of your turf management. It's the common sense way to cut mowing and trimming costs.

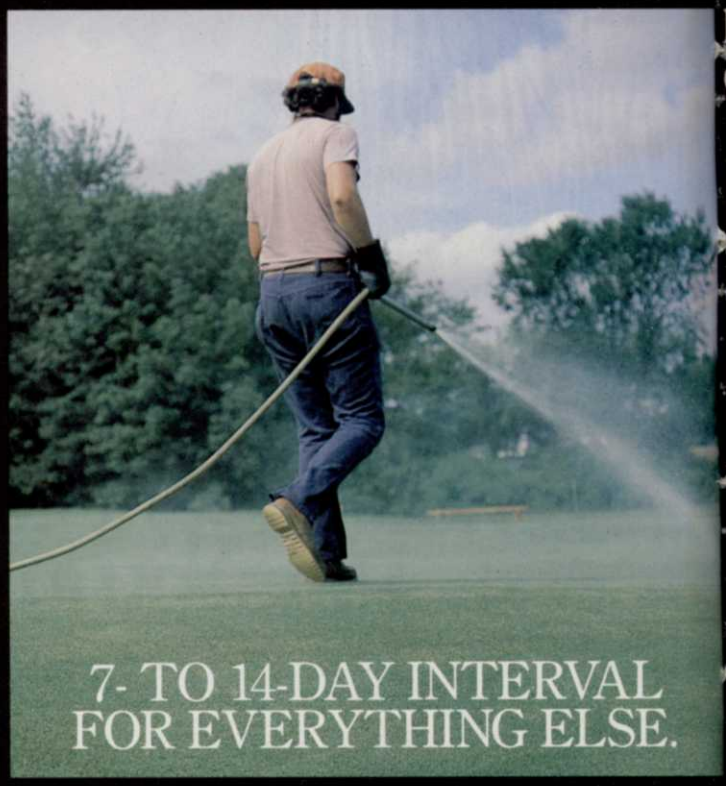
Distribution of "Embark" Plant Growth Regulator for commercial turf is planned for many areas of the country this season. For a listing of "Embark" Plant Growth Regulator distributors in your area, write: Agrichemicals/3M
223-6SE, 3M Center
St. Paul, MN 55101

3M

For ad on following page circle 124 on free information card

INTRODUCING CHIPCO®
THAT WILL OUTPERFORM
WITH ABOUT HALF T





Here's a new fungicide that could change your whole way of thinking about broad-spectrum fungus control *and* spray intervals. Because new Chipco 26019 gives more control with fewer sprays than any of the old fungicides you've had to use.

It stops the major turf diseases—dollar spot (including benomyl-resistant dollar spot), brown patch and Helminthosporium (leaf spot). And it does it for up to three weeks, at low, economical rates.

It's a nice material to handle, too. It mixes well, with no residual left in the tank. It also presents no problems of phytotoxicity to turf.

Last year was a wet one, with unusually high disease pressure in most areas. Yet, Chipco 26019 performed beautifully in wide-spread tests. This year, you'll have the chance to see how well it can perform for you. So ask your chemicals distributor for this welcome addition to the popular Chipco

6019. A TURF FUNGICIDE NYTING ELSE YOU CAN USE, E NUMBER OF SPRAYS.

line of turf fungicides and herbicides. It will outperform anything else you can use, with about half the number of sprays.

"YOU FOLKS HAVE SOMETHING GOOD HERE."

"The main reason I'll use Chipco 26019 is to control dollar spot. Picking up brown patch and the others is gravy, as far as I'm concerned. This is a real good new chemical."

—Bob Dickison, golf course superintendent
Upper Montclair Country Club, Clifton, N.J.

"I feel very good about this product. We tested it during one of the roughest summers in my memory. I think, over a 14-day period in August, we had very close to 10 inches of rain. It was an acid test for the material. These chemicals come and go, and some of them are short-lived. But you folks have something good here. The sprayability of Chipco 26019 is very impressive. And you only need six to 10 hours of drying time, which helps a lot during rainy periods. Some other materials require at least 12 hours."

—Paul Boizelle, golf course superintendent,
and John Fenwick, foreman,
Fiddler's Elbow Country Club, Far Hills, N.J.

"We started using Chipco 26019 in June of 1977. Before we started using it, we had very little luck with our other contact and systemic fungicides in certain areas. We were applying some contact fungicides at preventative and curative rates, and still only getting two or three days control, with the usual cold fronts coming through, followed by large outbreaks of dollar spot. Since we started using Chipco 26019, we haven't found dollar spots in these areas at all."

—Randy Wahler, golf course superintendent
Glen Flora Golf Course, Waukegan, Ill.

Rhône-Poulenc Inc. Agricultural Division,
Monmouth Junction, New Jersey 08852.

rhône-poulenc inc.

Please read labels carefully, and use only as directed.

hollow shaft for direct pto mounting or 1¼ inch solid shaft for coupling to pto tumberod.

The pump's positive displacement design, providing high pressure performance, makes it ideally suited for servicing long dischage lines on transfer equipment and large scale spray rigs which require higher pressures to supply extra boom nozzles and check valves. The pump handles a full variety of agricultural chemicals including plain water. An added benefit is its self-priming ability. It is self-priming to 10 ft. (lifts 22 ft. primed).

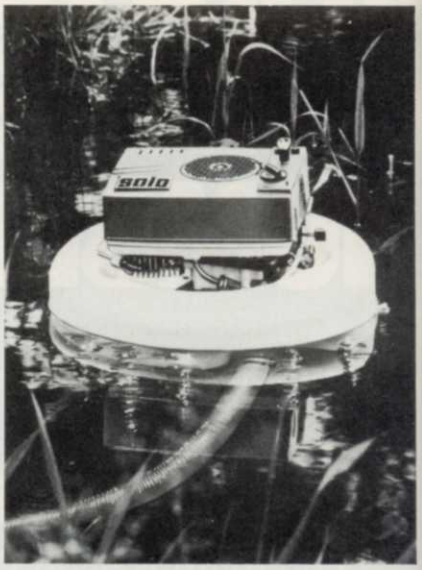
Circle 703 on free information card

The Off-Set is now offered by Terrain King Corporation. Off-Set has a cutterhead that delivers a full 5½ foot cut and utilizes a unique float system that allows this cutterhead to follow the contour of the terrain without operator control.

One feature is its exclusive, patent-pending shock absorbing system. This system acts as a release mechanism, allowing the cutterhead to move rearward when obstructions are hit. By doing so, it is both an accident preventor and cost eliminator. The action gives the operator added time to react and avoid sudden, dangerous jolts. And it protects tractor frames and bell housings from costly damage and repairs.

A second feature is the parallel linkage system. This system makes the Off-Set the only machine of its type that can lift the cutterhead over obstructions without tilting the outside edge upward and exposing the rotary blades. It can lift the cutterhead from 5 inches below grade to 13 inches above grade while maintaining a constant relative angle to the ground. This not only means added speed advantages, but overall machine safety.

Circle 704 on free information card



Solo announces the availability of its new Floating Pump, Model 830. Powered by one of the company's time proven 4 hp, 2-cycle engines (92 cc) displacement, 5.6 cu. in., it delivers up to 5,800 gallons per hour (22,000 litres per hour) to a total head of 100 feet (30m).

Encased in a unique plastic floating body; this pump is buoyant

Circle **131** on free information card

RELIABILITY

JUST ONE OF THE REASONS

SOD GROWERS IN 11 COUNTRIES WORLDWIDE PREFER THE BROUWER

- SIMPLE DESIGN and few moving parts provide the most efficient maintenance program on the market.
- PROVEN, DEPENDABLE, ECONOMICAL standard farm tractor and parts are used, greatly reducing obsolescence, depreciation, maintenance and down time.
- DEPENDABLE and Consistent Performance, cutting in ALL SEASONS, ALL GRASSES, ALL CONDITIONS — wet, dry, hard, soft, rough and even weak sod, day or night, rain or shine.
- Cuts a UNIFORM THICKNESS that's adjustable for minimum top soil removal.
- ROLLS, SLABS or FOLDS in accurate widths of 15'', 16'', 18'' or 24''.
- TROUBLE FREE ADJUSTABLE LENGTH CUT-OFF produces consistently clean, square cuts.
- REDUCED FIELD WASTE and NO TURF DAMAGE. Operates off the turf, follows field contours and cuts to fences, irrigation pipes and ditches.
- DEPENDABILITY that SAVES you TIME and MONEY.

YOU OWE IT TO YOURSELF TO INVESTIGATE NOW. CALL OR WRITE TODAY.

BROUWER

TURF EQUIPMENT LIMITED

THE ULTIMATE IN RELIABILITY, VERSATILITY & ECONOMY

Manufacturer: Woodbine Avenue, Keswick, Ontario, Canada L4P 3E9 Telephone (416) 476-4311

Circle **136** on free information card

and most important derives the liquid from the cleanest area — only inches below the surface, reducing priming time to almost nil. Suction hoses are not needed. The pump's central intake port is away from mud and grit and a screen protects the internal parts, which are made of high impact plastic.

Weighing only 26 lbs., this pump is easily transportable and was designed for its practicability and economy.

Circle 705 on free information card

Vertifiers and Aerifiers

MC-5C Vertifier
Fast, straight-in, straight-out coring. Core catcher. High speed. Minimum surface disturbance. Hydraulic lift for easy maneuvering.

JR-3 Aerifier®
Self-propelled aerifier for greens and general purpose. Fast, maneuverable, low maintenance. Scoops out small, pear-shaped, loose-walled cavities to admit air, water, and fertilizer to grass roots.

TM-140 Aerifier®
Easiest, fastest, most maintenance free aerifier. Built-in weight racks. Rigid frame construction. Aerifying spoons or double-point diamond slicing blades available for double duty. Patented Flexi-press springs fit over spoons to prevent turf tearing. Models for 3-point hitch or pull-behind, hydraulic lift.

Ask your Hahn Distributor about other Hahn Turf Products.

Hahn TURF PRODUCTS DIVISION
1625 N. Garvin, Evansville, Indiana 47711

Circle **154** on free information card

The newest and smallest member of the Water-Winch traveling sprinkler line is announced by Ag-Rain, Incorporated. The WW-1400M is designed specifically for use on small acreage, and should be of interest for farmers; flower, fruit and vegetable growers; athletic fields and parks; sod farms and golf courses.

Powered by A-Rain's exclusive patented radial inflow turbine drive, the WW-1400M has infinitely variable travel speeds with 1000 foot maximum travel distance. This compact traveling sprinkler has wide flotation tires and uses 2½" hose that can be reeled onto the built-in hose spool by attached PTO shaft. The WW-1400M has a flow capacity of 60 to 150 gallons per minute and incorporates most of the proven features of the larger Ag-Rain travelers.

Circle 706 on free information card

The new Davis W4, a compact ½ yd³ articulated loader with standard features normally found on larger equipment, was recently introduced by The Davis Division at J I Case.

The economically-priced W4 is powered by a standard 26.4 kW (35 hp gross) 4-cylinder liquid-cooled diesel engine, and was designed to handle a wide range of construction and utility loading jobs. Other standard features include 4-wheel hydrostatic drive with mechanical 2-speed transmission, a mechanical self-leveling bucket, bucket level indicator gauge, power steering, easy loader controls, and an electric cold-start preheat system.

Center-pivot steering allows 70° total hydraulic articulation — the front and rear wheels always follow the same track. Combined with total frame oscillation of 16°, the W4 provides stable ground contact over rough terrain.

The new loader has a total breakout force of 2381 kg (5250 lbs) and total hydraulic lift capacity of 2858 kg (5700 lbs) at ground level. Maximum loading height for the W4 with full dump clearance is 3121 mm (91.4").

Circle 707 on free information card

Continues on page 87

The Musser Foundation . . . An Investment in the Future

THE MUSSER INTERNATIONAL TURFGRASS FOUNDATION

of the H. B. Musser Turfgrass Fellowship, Inc.

We are a non-profit, tax-exempt, charitable and educational, IRS approved corporation. We are building a fund that perpetually will create income which will be used through graduate fellowships to train and educate leaders in the turfgrass field who will fill vacancies created when our active scientists retire. For some of our top leaders that time is NOW! Fellowships involve closely supervised original basic research at a recognized experiment station and the writing of a learned thesis.

Our officers, directors and advisers are qualified to offer assistance in several categories:

Benefit Tournaments can be structured to help state experiment station research as well as MITF.

Memorial Funds honor the dead with a Living Fund that supports higher education in turfgrass forever. Several currently are in existence.

Trusts can be developed by our specialists to benefit both the donor and MITF.

Contributions always are welcome in any amount. Donations will be gratefully acknowledged and the donor's name will be permanently inscribed on the Fellowship rolls.

For further information please fill out the coupon below.

Mail to: Mr. Ben O. Warren, Treasurer, 8400 W. 111th St., Palos Hills, IL. 60465.

Check appropriate box(es) and a brochure will be sent with further information.

- ☐ Benefit Golf Tournaments
- ☐ Memorial Funds
- ☐ Charitable Remainder Trusts
- ☐ Contributions: ( ) $1,000; ( ) $500; ( ) $250; ( ) $100; ( )

Name _____

Club or Organization _____

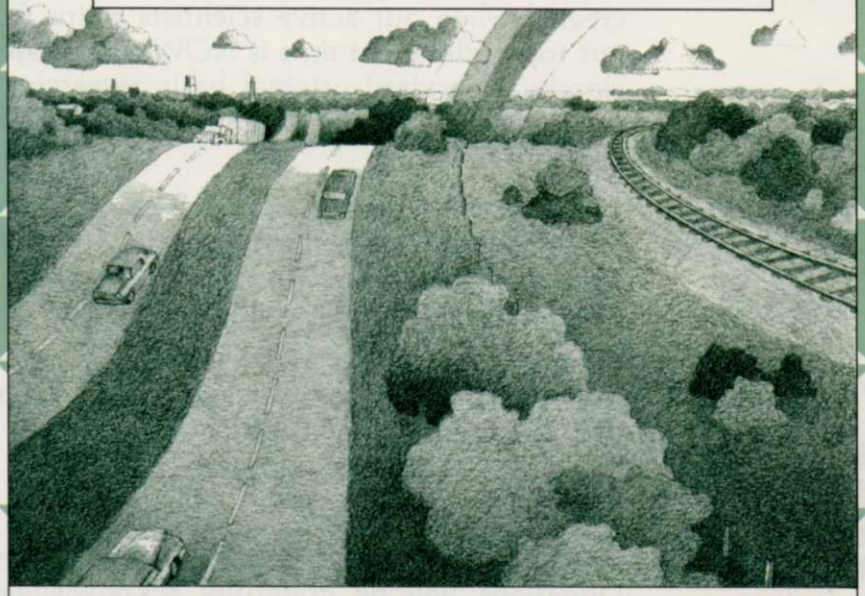
Address _____

City _____ State and Zip Code _____

Telephone _____

CRYSTAL

PHYTAR 560® · BROADSIDE™

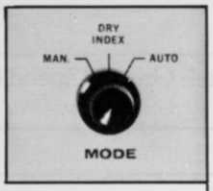


GENERAL NON-SELECTIVE HERBICIDES

For general post-emergent weed control in non-crop areas Crystal Chemical Company makes Phytar 560 and Broadside. Both are Cacodylic Acid type herbicides, and Broadside also contains MSMA. Both products can be used for fast knockdown of weeds along highways, rights-of-way, around buildings, fence rows, playgrounds, drainage ditches, golf courses, and railways. Phytar 560 is safe for use around ornamentals and non-bearing citrus orchards, while Broadside's effective root-kill is ideal for controlling tough perennials. Both provide complete weed control without soil sterility. So don't let unsightly and hazardous weeds control you. Control them with Phytar 560 or Broadside.

Crystal Chemical Company
1525 North Post Oak Road
Houston, Texas 77055
(713) 682-1221

Circle **111** on free information card



WE WROTE THE BOOK ON CONTROLS

Weather-matic controllers can operate any size sprinkler system effortlessly and automatically, on almost any type of watering program. Our reliable electronic controllers offer automatic, semi-automatic or manual operation; variable timing, 14-day calendar programming, dry indexing; Rain-Stat®; modular expandable and command/satellite models.

THE TURF IRRIGATION MANUAL
A definitive reference book on landscape irrigation just published by Telsco. Copies may be ordered from the factory.

MAIL TO: Weather-matic Division Telsco Industries • Box 18205C • Dallas, Texas 75218

Please send me information on

( ) Residential controllers
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( ) Turf Irrigation Manual

NAME _____
COMPANY _____
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CITY _____
STATE _____ ZIP _____

Weather matic.

Circle **169** on free information card

Massey-Ferguson introduces six new compact tractors designed to meet increasingly important uses for tractors in the smaller size range. The new line features high cubic-inch-displacement diesel engines ranging from 20 to 31 engine horsepower (16 to 26 PTO hp). Three of the six are among the few four-wheel-drive machines available in North America in this power range.

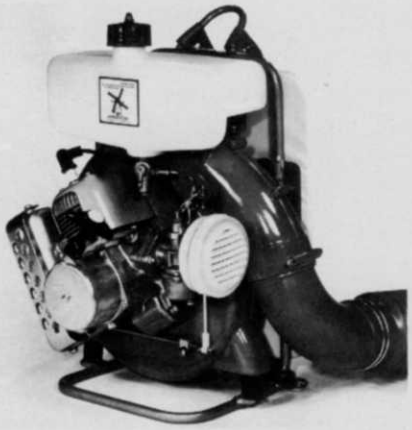
The six tractors are the 20-hp MF 205, the 25-hp MF 210 and the 31-hp MF 220 plus their four-wheel-drive counterparts, the MF 205-4, the MF 210-4 and the MF 220-4.

The MF 210 and MF 220 two-wheel-drive tractors feature adjustable, swept-back front axles as standard equipment. The other four models have standard axles. Differential locks and both hand and foot throttles are standard.

All models are equipped with a 540-rpm, transmission-driven rear PTO with overrunning clutch. Front PTO capability will be available on all models.

The new small tractors feature large-capacity hydraulic pumps. These provide position control for the hydraulic linkage on the MF 205 and MF 210.

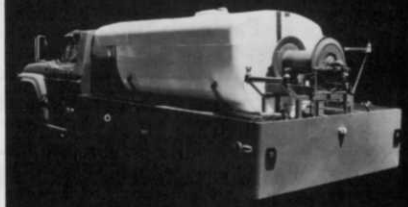
Circle 708 on free information card



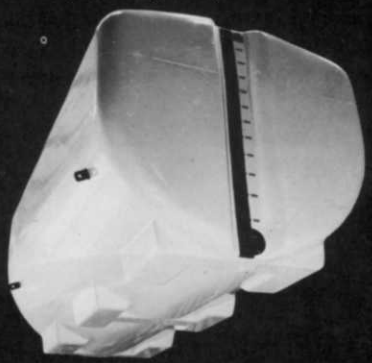
Vandermolen's new Windmill 55B Backpack Blower features a "tilt-proof" fuel tank. The unique shape of the fuel tank with its downward sloping bottom, feeds fuel to the carburetor even when the blower is tilted sideways or forward on the

LASTS A LIFETIME
Tuflex® MFG. CO.
FIBERGLASS PRODUCTS

WHEN THERE'S NO SUBSTITUTE FOR THE BEST!



Model #PC 1200 fiberglass tank equipped with fiberglass pump cover, Model #D 200 gallon mixing tank shown mounted on a custom truck body by Strong Enterprises.



Bottom view of the Model #PC 1200 tank showing to best advantage the integral molded mounting base and steel hold-down lugs designed for ease in mounting on your truck and eliminating costly installation.

THE Tuflex Manufacturing process allows a five year warranty on all tanks.

Tuflex is the only manufacturer to specialize in *seamless* fiberglass spray tanks specifically for the pest control and lawn care industry. Remember when craftsmanship was an art... at Tuflex it still is! The exclusive Tuflex process carries a full five year warranty on all handcrafted seamless fiberglass tanks.

For economy prices and more information on our complete line of tanks, write or call now:

Tuflex Manufacturing Company
Post Office Box 13143
Port Everglades, Florida 33316
(305) 525-8815

Circle **110** on free information card

WHAT'S INSIDE IT A BET

If you're hardnosed about business decisions, you want to get the in-depth facts on a product before you buy. That's why we've put together this head-to-head comparison between the insides of an E-Z-GO and a Cushman. We took comparable top-of-the line models, E-Z-GO's GT-7 and the Cushman Turf Truckster. Here's what we found.

Power Source: 18 horsepower OMC engine, tightly compartmentalized. Ground speed 0 to 22 mph.

Braking: Hydraulic internal expanding.

Payload: 1000 pounds.

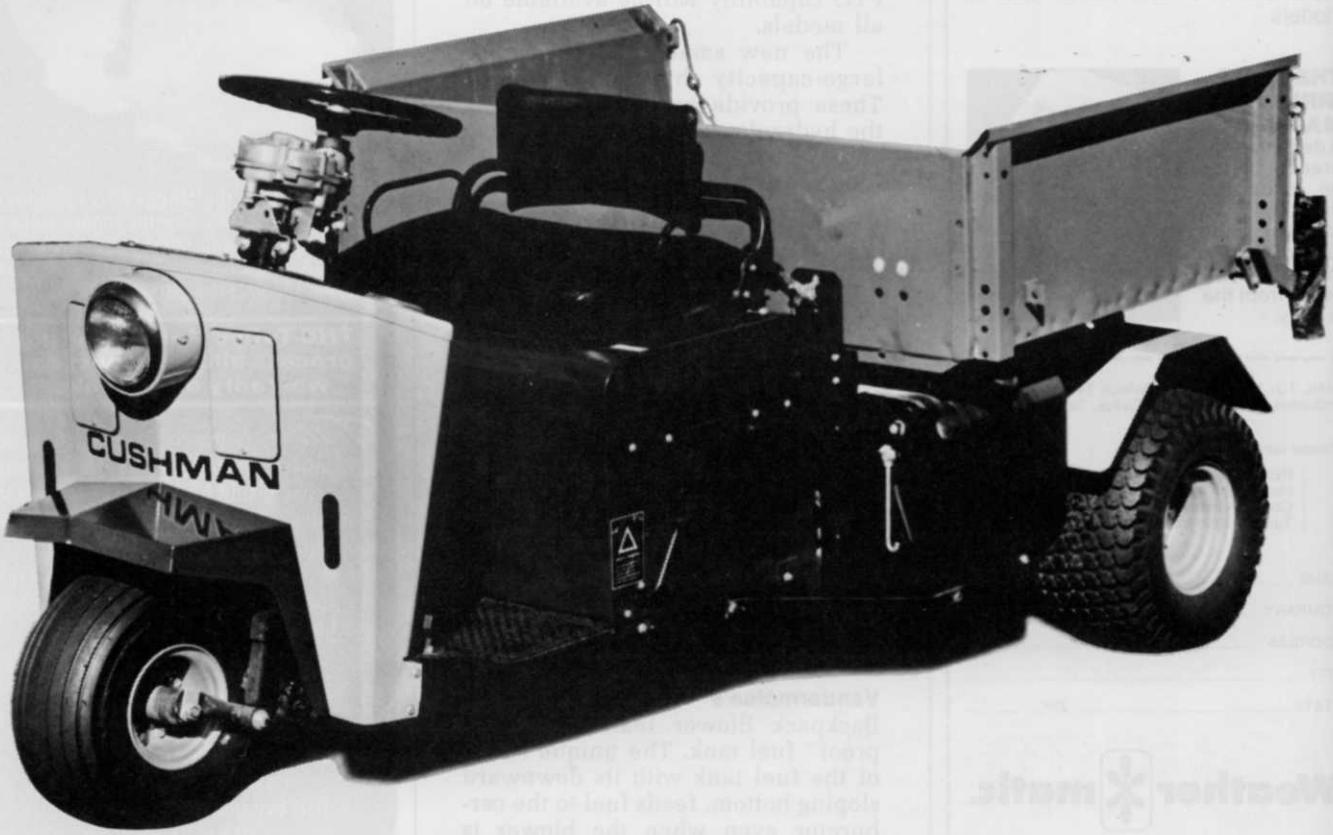
Suspension System: Torsion bars, leaf springs, front and rear shocks.

Dump Construction: Single wall.

Headlights: Single.

Seating: Single seat for one passenger with back rest and hip restraint.

Price: Virtually the same.



AN E-Z-GO MAKES TER BUY.

Power Source: A rugged, reliable 18 horsepower Onan engine with the power to carry a full payload up to 24 mph. Substantially larger engine compartment for easier maintenance.

Braking: Improved hydraulic internal expanding.

Payload: 1500 pounds. A massive 50% greater carrying capacity than Cushman. More cubic space for greater material volume.

Suspension System: Heavy duty torsion bars, leaf springs, front and rear shock absorbers, designed to support the bigger payload.

Dump Construction: Heavy duty diamond plate steel with rugged rear bumper for heavier loads and longer life. Easily convertible to flat bed.

Headlights: Dual lights for greater night vision.

Seating: Dual seats for two passengers with individual back rests and hip restraints, constructed for larger men, greater comfort.

Price: Virtually the same.

Summary: E-Z-GO carries a greater payload, is easier to maintain, is larger, more durably built, and safer with a wider wheel base. E-Z-GO uses top quality components from companies such as Bendix, Borg Warner, Dana, Onan, and Rockwell International.
For the complete story on the E-Z-GO GT-7, a demonstration on your course, contact your E-Z-GO distributor. For his address check your Yellow Pages or call or write Mr. William Lanier, E-Z-GO, P.O. Box 388, Augusta, Georgia 30903, at (404) 798-4311.

E-Z-GO TEXTRON
Polaris E-Z-Go Division of Textron Inc.

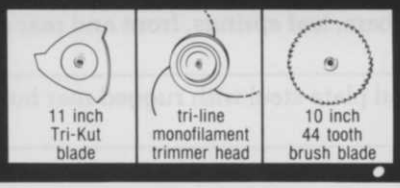
Circle **153** on free information card

HOFFCO ™
Whizz Witch

A tough 85cc engine stands behind trimming head and 2 cutting blades.

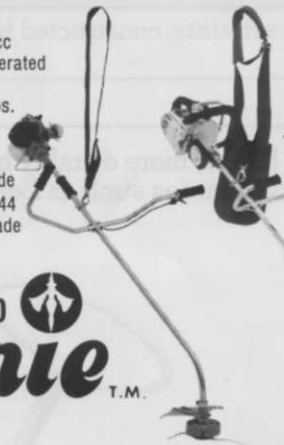
- Tri-line, heavy duty monofilament trimmer head.
- 11″ Tri-Kut weed blade cuts heavy weeds, briars and brambles.
- 10″ 44 tooth brush blade (optional) cuts up to 3″ diameter saplings at ground level.

HOFFCO-P10-A
BRUSHCUTTER/POWER SCYTHE
Offers the same equipment package, but the trimmer head is optional.



The 2 cycle, 22.5cc engine, can be operated in any position. Total wgt. 13½ lbs.

1. Monofilament trimmer head
2. 8″ Tri-Kut blade
3. (optional) 8″–44 tooth brush blade



HOFFCO
Brushette T.M.
Special merchandising displays available.

CHAIN SAW ATTACHMENT
Also attaches easily to most lightweight chain saws. • 8″ Tri-Kut weed blade • 8″ 44 tooth brush blade • optional monofilament trimmer • Use for overhead tree and brush trimming.

HOFFCO'S "HUMAN ENGINEERING"
The carrying harness and handlebars with anti-vibration grips can be adjusted for the comfort, balance and separates operator from cutting and trimming heads.

HOFFCO
genie T.M.

Whizz Winch TM
1,000 lbs. of pulling power
Does the work of 10-20 people
14′ of working cable

"Hoffie"

HOFFCO
PH 977-A
A true ONE MAN post hole drill Full wrap-around handles *deadman throttle control and kill switch on handle *Comet auto *centrifugal clutch *18.1 power ratio 2 to 8″ earth bits *8″ ice bit available. Drill to 30″ (4′ with extension accessory).

HOFFCO PH 1100-A 2-man
4-cycle engine. Special throttle control and auto. centrifugal clutch.

Write for free brochures & name of Distributors in your area . . .

DEPT. WTT-379 • 358 N.W. "F" STREET • RICHMOND, IN 47374

Circle **155** on free information card

back of the operator.

The Windmill Backpack Blower is designed for commercial use. The "tilt-proof" fuel tank has over a ½ gallon capacity for 2 to 2½ hours of continuous operation. This blower has the features that professional users want on a backpack blower: powerful airblast, rugged build, dependable performance, and full control of airblast direction.

Circle 709 on free information card

The Model 300 Shredder-Mixer, a high capacity organic materials processor, has been introduced by the Environmental Products Division of Royer Foundry & Machine Co., Kingston, Pa. The new unit is sized for processing topsoil, composted leaves and sewage sludge, peat, and other organic materials.

The all-hydraulic, diesel-powered Model 300 features Royer's patented cleated-belt which provides continuous four-step processing that shreds, mixes, and aerates up to 75 cubic yards of material per hour while automatically separating non-shreddables.

The power system on the Model 300 combines a 58 hp diesel engine with hydraulics to produce smooth performance. Hydraulic controls permit the operator to govern the speed of the conveyor as it feeds material to the shredding belt.

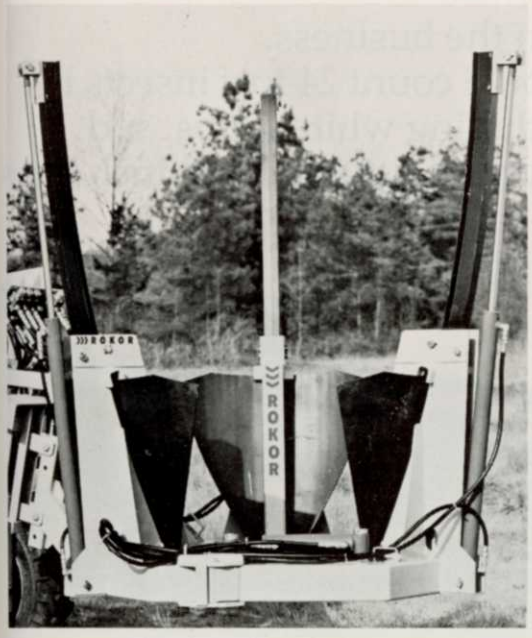
Loaders of 1½ or 2 cubic yards can be used to fill the shredder-mixer's 2.34 cubic yard receiving hopper. In operation a 20-inch inclined conveyor belt, built into the large hopper, delivers material to the machine's high speed, patented shredding belt. Thousands of tempered steel cleats on the belt shred the material in an endless raking action, and discharge it through adjustable, variable sweep fingers. Rejected sticks, stones, woodchips and other trash roll back to a refuse chute for separate discharge. The high discharge of the shredder-mixer permits stockpiling or direct loading of trucks.

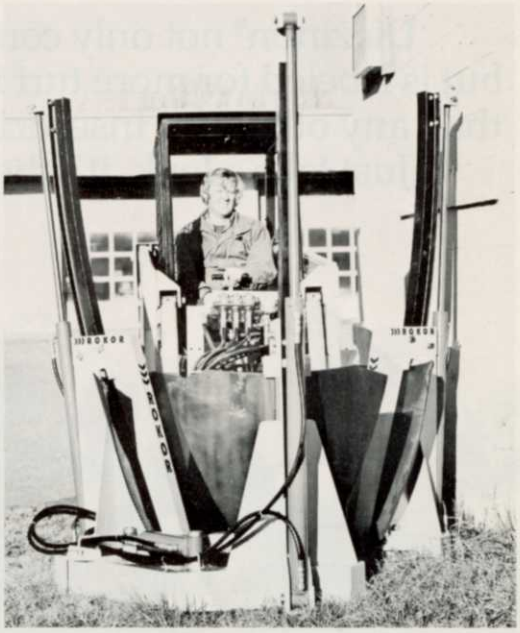
Circle 710 on free information card

ROKOR

TREE DIGGERS

PRECISION-BUILT FOR DEMANDING PROFESSIONALS





MODEL TD-32. Weight—1,070 lbs. Digs a 420 lb. ball; a true 32" wide and 28" deep; trees up to 3" diameter. Complete with hydraulics and adapter for skid loader or tractor mounting. As shown.

MODEL TD-40. Weight—1,600 lbs. Digs a 950 lb. ball. Ball is a true 40" wide; 38" deep. Handles trees up to 4" in diameter. Furnished complete with hydraulics, adapter and lift attachment, if required.

MODEL TD-54. Weight will vary depending on choice of type of truck or heavy loader mounting. Digs a 2,100 lb. ball that is a true 54" wide and 46" deep. Designed to handle trees up to 6" in diameter.

- Rokor Diggers are light in weight to extend your mounting options but are designed stronger and tougher by Rokor Engineers to withstand the most rugged operating conditions.
- Curved stems require less operating space and can work the more heavily planted areas. The TD-32, for example is only 71½" wide when open and can plant or dig within 36" of a wall or fence.
- Spoon-shaped blades produce a true nurseryman's ball and opposite-side blade sharpening means tighter cones and clean root shear. Computer programmed to insure uniformity. Choice of sand or clay blades with quick blade change in the field.

DISTRIBUTED EXCLUSIVELY BY
Spartan Tree Equipment Company
16084 South Chandler Road
East Lansing, Michigan 48823
517/351-1370

MANUFACTURED BY ROKOR, INC. • P.O. BOX 1409 • WILSON, NORTH CAROLINA 27893

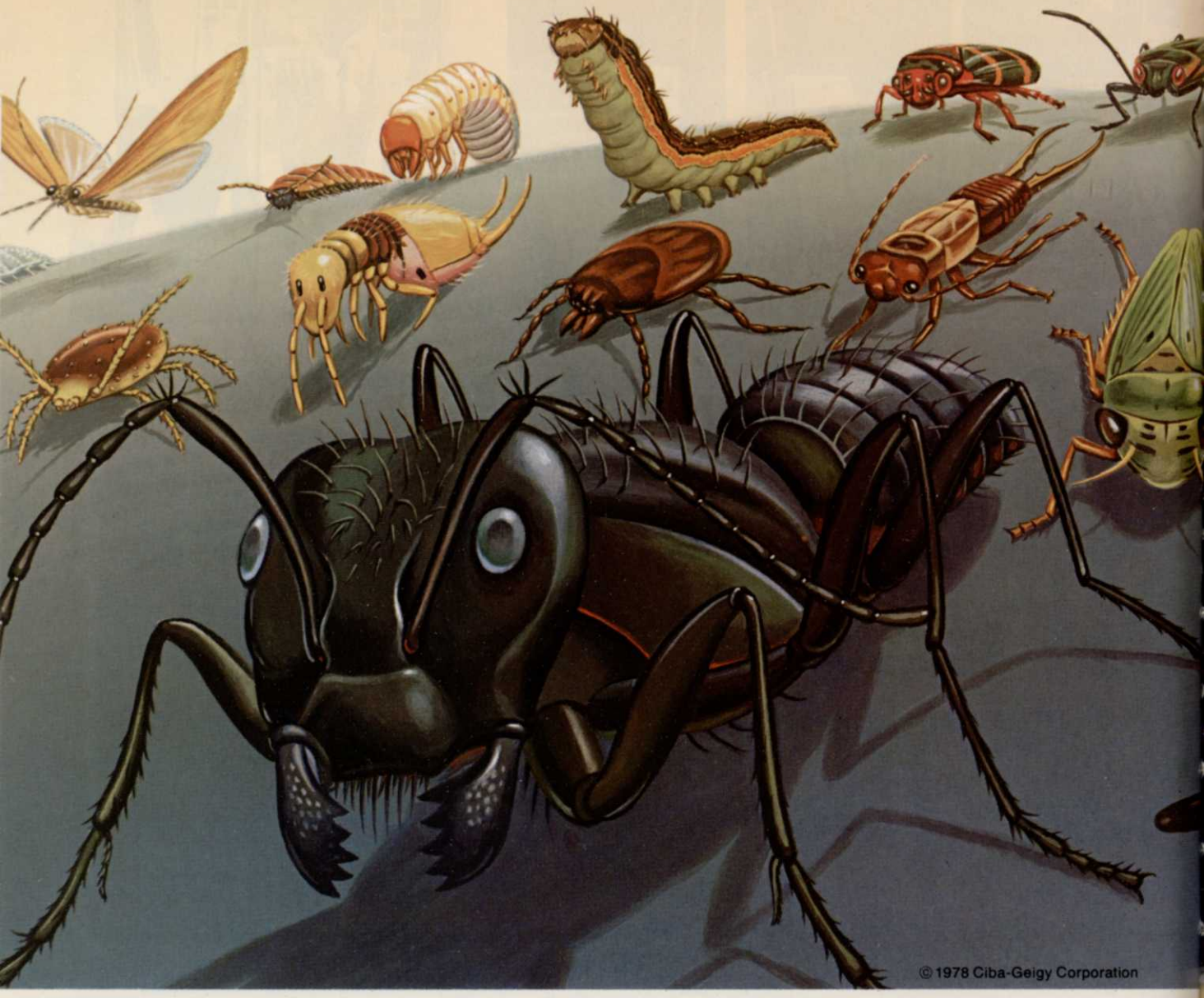
Circle **166** on free information card

Diazinon is labeled for
How many will you

Diazinon® not only controls, but is labeled for more turf insects than any other turf insecticide.

Just take a look, it's the biggest label in the business.

You'll count 24 turf insects in all. Including white grubs, sod webworms, cutworms, chinch bugs,



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every insect on this page. face this season?

armyworms and ants.

This season, be sure to ask your local supplier for Diazinon.

And put the biggest label in the business to work for you.

Ciba-Geigy, Ag. Div., Box 11422, Greensboro, NC 27409

Diazinon by CIBA-GEIGY
The biggest label in the business.

CIBA–GEIGY

Circle **164** on free information card

Proven over 15 years

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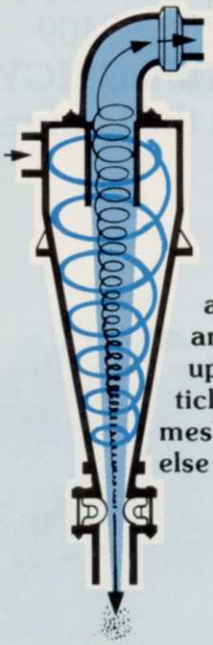
The old hydrocyclone (left) did a good job. But our separator (at right) is better. No high speed abrasion. No plugging the apex. No screens or filter elements to clean or replace.



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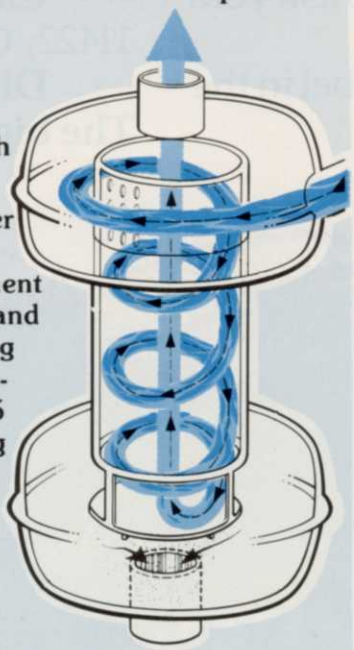

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grown seedlings are not always superior. In fact, survival and subsequent growth have sometimes been less than with standard nursery-grown seedlings.

At the same time, the basic problem is one of cost, Dr. Hutnik observed. To compete with nursery-grown seedlings, containerized seedlings must be grown for no longer than one year prior to transplanting, in contrast to the two to four years normally needed to produce certain conifers in nurseries. The older seedlings, it was noted, are better able to withstand competition from other vegetation and tolerate late frosts and droughts that often occur following spring planting.

"If the springtime has sufficient, well-distributed rainfall and no severe late frosts, and if weed and grass cover is not too dense, containerized seedlings survive as well or better than bare-root stock," Dr. Hutnik affirmed.

"This apparently explains the good results we had with our container-grown seedlings in 1978, as compared to relatively poor results in 1977," he added.

The container-grown method has several attractive features, it was pointed out. It conserves seed that is expensive or in short supply, such as seed from genetically superior trees. It improves flexibility in planning and in responding to unexpected developments, since the time from sowing of seeds to outplanting is shortened by a year or more. And it permits the planting season to be extended later than normal into the growing season, since the roots in containers are disturbed only slightly.

"For these reasons, more and more containerized seedlings are likely to be planted as part of reclamation programs on newly mined land as well as to rehabilitate old strip mines lacking adequate vegetation," Dr. Hutnik predicted. He indicated, however, that bare-root nursery stock will continue to be the chief means of reforesting strip-mined land, at least in the near future.

Meanwhile, research is underway at Penn State to develop and evaluate new or improved containers and methods of handling them. Experiments are seeking improved greenhouse environmental systems. The latter stress interaction of various types and combinations of irrigation, fertilization, supplemental night lighting, and supplemental cooling and heating.

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were quite common and some varieties showed over 50% damage. In the same test, Enmundi was one of the few varieties classed as showing good resistance to striped smut.

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Another serious bluegrass disease, Helminthosporium, has not troubled Enmundi anywhere. It also has exhibited excellent resistance to rust and to brown patch, according to NAPB.

In studies at Penn State, Enmundi was singled out as having a more pronounced horizontal growth habit than is usually observed in bluegrasses. This characteristic generally associated with the ability of grass to perform well under low mowing heights.

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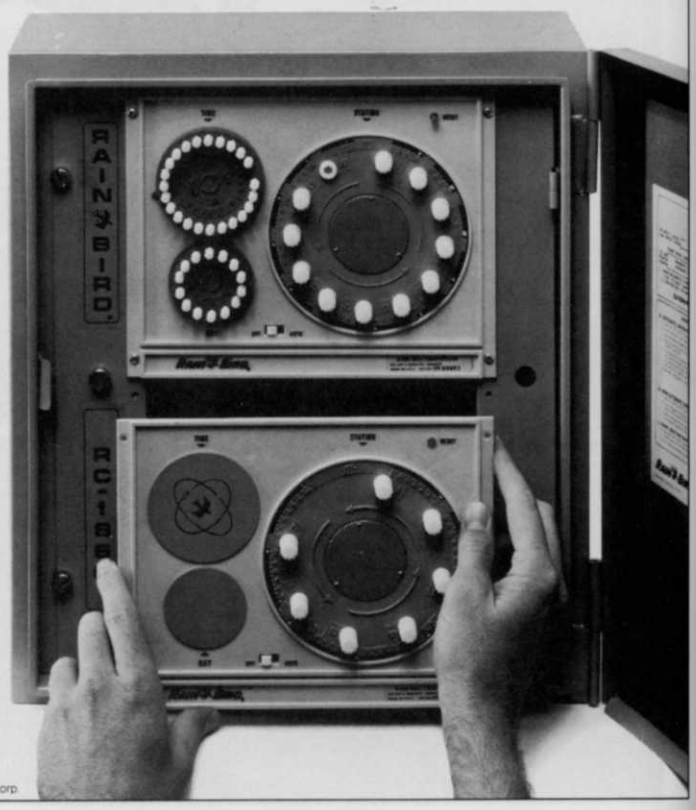

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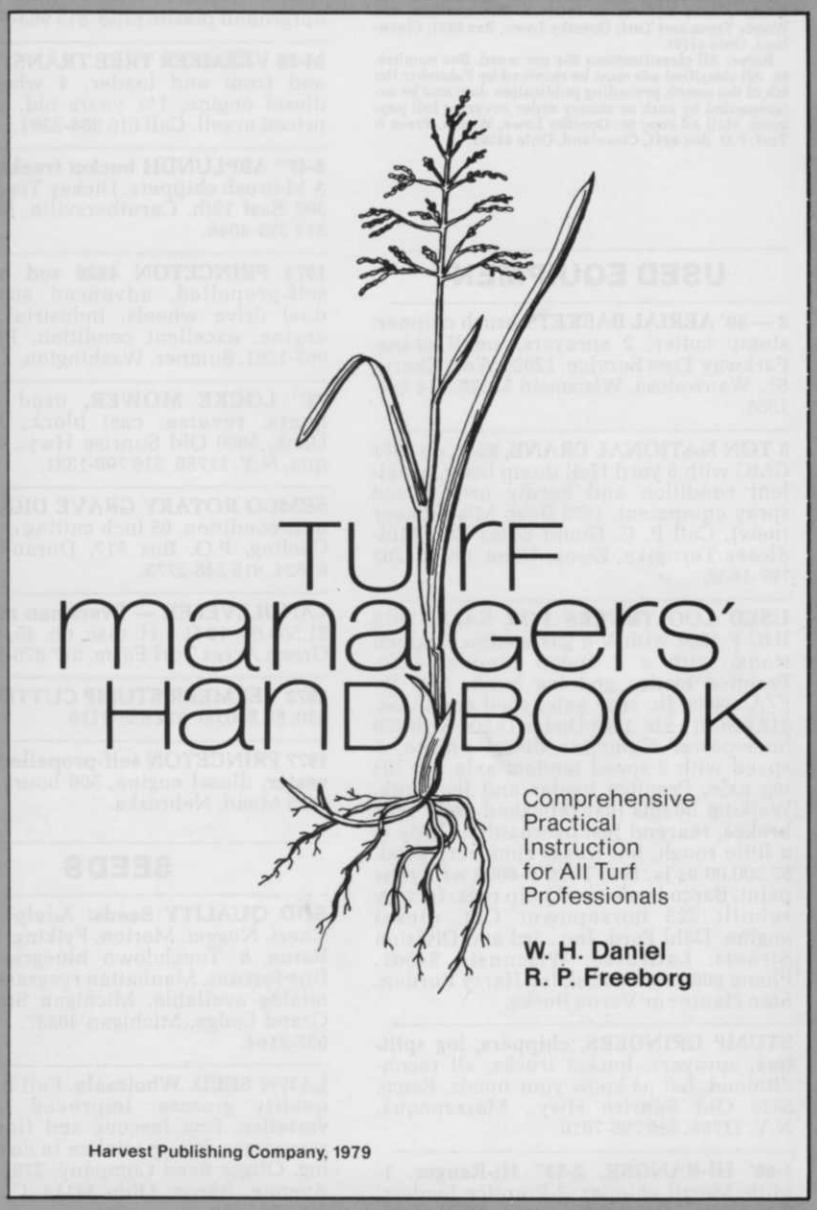

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A Symposium on Turfgrass Diseases, Ohio State University, OARDC, & Chemlawn Corp., University Holiday Inn, Columbus, Ohio, **May 15-17.** Write: A Symposium of Turfgrass Diseases 1979, 2865 E. Orange Rd., Galena, OH 43021, or phone: Dr. P. O. Larsen, 614/422-6987, or Dr. B. G. Joyner, 614/885-9588.

Western Chapter, International Society of Arboriculture, Rochelle's, Long Beach, Calif., **May 17-18.** Contact: E. C. Bundy, phone: 217/328-2032.

Texas A&M University Turfgrass Research Field Day, TAMU Turfgrass Field Lab, Agronomy Road, TAMU Campus, College Station, Tex., **May 24.** Contact: Dr. Richard Duble or James Beard, Department of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843.

Quebec Chapter, International Society of Arboriculture, Laval University, Quebec City, Quebec, Canada, **May 25-28.** Contact: E. C. Bundy, phone: 217/328-2032.

The Fertilizer Insititute Marketing Conference, The Greenbriar, White Sulphur Springs, W. Va., **June 10-13.** Contact: Doug Culkin, TFI, 1015 18th St., N.W., Washington, DC 20036, 202/466-2700.

Texas Chapter, International Society of Arboriculture, La Mansion Motel, San Antonio, Tex., **June 15-17.** Contact: E. C. Bundy, phone: 217/328-2032.

1979 Rutgers Research Field Day, Adelphia Research Center, Adelphia, N.J., June 20. Contact: Ralph Engel, phone: 201/932-9427.

American Seed Trade Association, Annual Conference, Hyatt Regency Hotel, Washington, D.C., **June 24-28.** Contact: Association, Executive Building, Suite 964, 1030 15th St., N.W., Washington, DC 20005.

Michigan Turfgrass Field Day, Crops Barn, Michigan State University, East Lansing, **July 10.** Contact: Dr. John E. Kaufmann, 322 Agriculture Hall, MSU, East Lansing, MI 48824.

Penn Allied Nursery Trade Show, Hershey Convention Center, **July 24-26.** Contact: S. Howard Davis, 169 W. High St., Carlisle, PA 17013, 717/243-1786.

Massachusetts Turf Field Day, South Deerfield Turf Plots, **July 25.** Contact: Dr. Joseph Troll, Stockbridge Hall, University of Massachusetts, Amherst, MA 01003, 413/545-2353.

American Sod Producers Association, Summer Convention and Field Days, Hilton Inn East, Columbus, Ohio, **July 18-20.** Contact: Bob Garey, ASPA, Association Building, 9th and Minnesota, Hastings, NE 68901, 402/463-5691.

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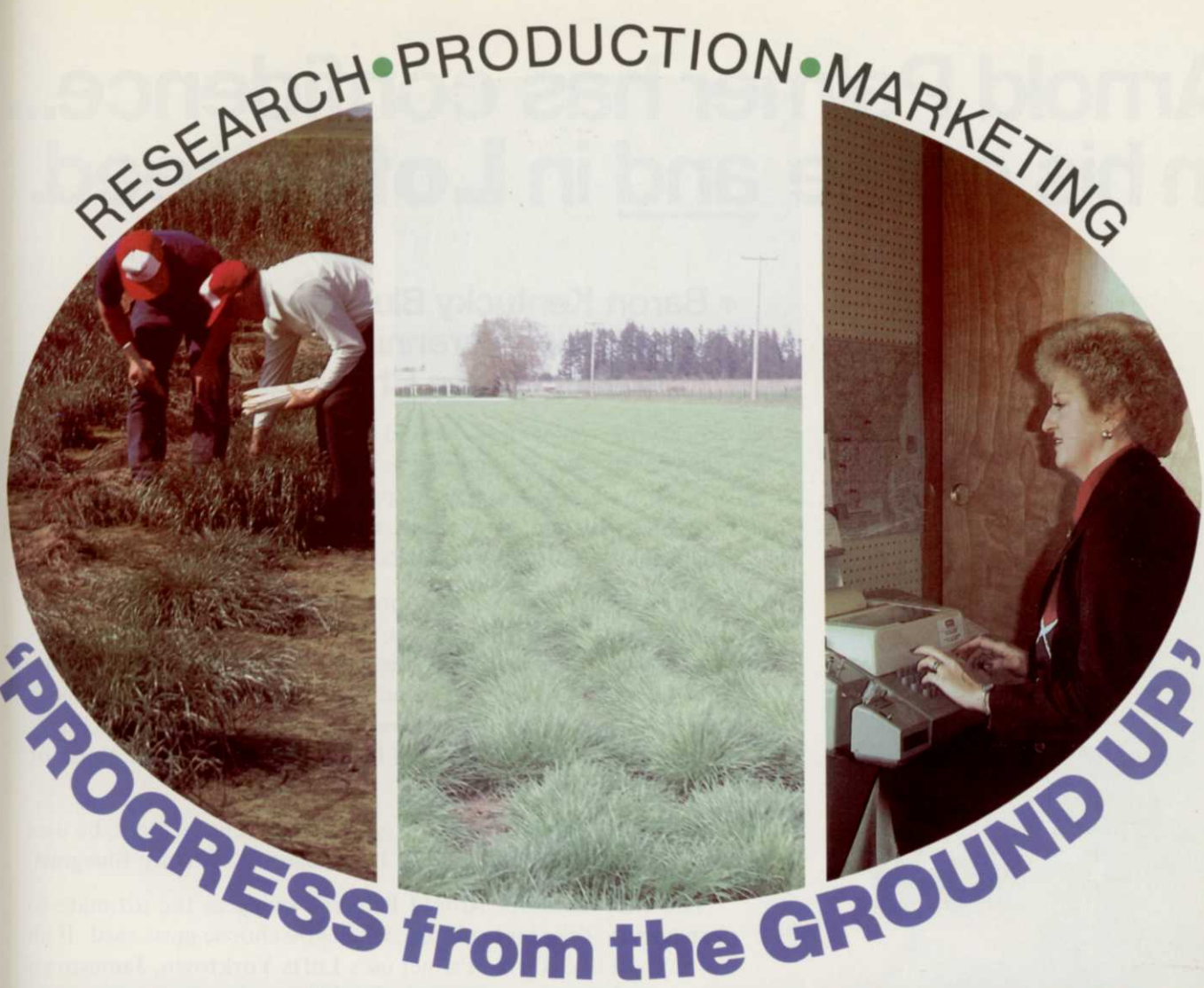

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Arnold Palmer discusses his overseeding program at Bay Hill with Peter Loft.

Note: The Bay Hill Club and Lodge will host the Florida Citrus Golf Classic.